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47TH CONGRESS, 1st *Session.* } HOUSE OF REPRESENTATIVES. { Ex. Doc. No. 98.

MINING DÉBRIS IN CALIFORNIA RIVERS.

LETTER

FROM

THE SECRETARY OF WAR,

TRANSMITTING

A final report upon the system to prevent further injury to the navigable waters of California from mining débris.

MARCH 7, 1882.—Referred to the Committee on Commerce and ordered to be printed.

WAR DEPARTMENT,
Washington City, March 6, 1882.

The Secretary of War has the honor to transmit to the House of Representatives, for the information of the Committee on Commerce, in further compliance with provisions in the river and harbor act of June 14, 1880, a copy of the final report of Lieut. Col. G. H. Mendell, Corps of Engineers, upon examinations and surveys to devise a system of works to prevent the further injury to the navigable waters of California from the débris of mines arising from hydraulic mining, together with the letter of the Chief of Engineers, dated the 6th instant, forwarding the same to this department.

ROBERT T. LINCOLN,
Secretary of War.

The SPEAKER
of the House of Representatives.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., March 6, 1882.

SIR: The river and harbor act of June 14, 1880, made provision for such examinations and surveys as might be found necessary to devise a system of works to prevent the further injury to the navigable waters of California from the débris of mines arising from hydraulic mining, and required a report thereon to be transmitted to Congress during its next session.

As in the report accordingly submitted January 31, 1881, it was not possible, for want of time, to cover the whole field of inquiry, I now have the honor to submit a copy of the final report upon this subject, with appendixes and maps, received from Lieut. Col. G. H. Mendell, Corps of Engineers, under whose direction the required examinations and surveys have been made.

Very respectfully, your obedient servant,

H. G. WRIGHT,
Chief of Engineers, Brig. and Brt. Maj. Gen.

Hon. ROBERT T. LINCOLN,
Secretary of War.

UNITED STATES ENGINEER OFFICE,
San Francisco, Cal., February 2, 1882.

GENERAL: I have the honor to transmit, in a separate package by mail, the final report upon the protection of the navigable waters of California against the effects of hydraulic mining.

The paper consists of the main report, and sub-reports as appendixes, four in number. The illustrations are three maps, which are those contained in House Ex. Doc. No. 76, Forty-sixth Congress, third session, with some additions of names and a little extension of the drainage lines on the Feather. * * * It is supposed the original plates may be used. The maps are: The general map of parts of the Sacramento and San Joaquin Valleys, the map of a portion of the Yuba, and of a portion of the Bear River Valley.

It is suggested that Lieutenant Payson's report, as printed in Ex. Doc. 76, before referred to, be reprinted, preceding the more detailed report herewith transmitted, as Appendix I.

A table of contents accompanies the report.

I am, very respectfully, your obedient servant,

G. H. MENDELL,
Lieut. Col., Corps of Engineers.

The CHIEF OF ENGINEERS, U. S. A.

REPORT

UPON A

PROJECT TO PROTECT THE NAVIGABLE WATERS OF CALIFORNIA FROM THE EFFECTS

OF

HYDRAULIC MINING.

BY

LIEUT. COLONEL G. H. MENDELL,
CORPS OF ENGINEERS, U. S. A.

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MAPS AND DRAWINGS.

Map of mining field, map of lower Yuba River, map of lower Bear River.

REPORT.

UNITED STATES ENGINEER OFFICE,
San Francisco, January 26, 1882.

GENERAL: I have the honor to submit the following report upon the subject referred to in the clause of the river and harbor act of June 14, 1880, here quoted:

> The Secretary of War is hereby directed to cause to be made such examination and surveys as may be necessary to devise a system of works to prevent the further injury to the navigable waters of California from the débris from the mines, and the estimates of the cost of such works, and report the result of such examinations, surveys, and estimates of cost of proposed works made in pursuance hereof to Congress at its next session.

INTRODUCTION.

The operations under the statute during the season of 1880 were the subject of a report submitted January 10, 1881, which was published by the House of Representatives, Forty-sixth Congress, third session, Ex. Doc. No. 76.

This report included as an appendix a report of Lieutenant Payson, giving the general results of the surveys and examinations made by a party under his direction, during the months of August, September, October, and November, 1880, on the following tributaries of the San Joaquin River, namely, the Cosumnes, Dry Creek, Sutter Creek, Mokelumne, Calaveras, Stanislaus, and Tuolumne Rivers.

Information in regard to the extent of mining, past and present, the prospects of the industry, the amount of water used, the quantity of gravel washed, the condition of the river beds, the necessity for storing material, the storage sites and estimates of cost, will be found in this report. Plane table maps were made of the valleys of these streams for a number of miles in the foot-hills, which, in general, present the most favorable sites for storage. The slopes of the river beds were also determined, and the levels were connected with bench marks of the State Engineer Department.

The conclusions of Lieutenant Payson as to the future prospects of hydraulic mining in this section of the country were unfavorable.

A more detailed report has since been submitted by Lieutenant Payson, which is transmitted as Appendix A of this report. These reports will be considered in this paper.

In the autumn of 1880 a survey of the American River, from the foothills to its mouth, was made by a party under the direction of Marsden Manson, assistant engineer. The map had not been completed at the date of the report of January 10, 1881.

It has since been completed.

Field work was necessarily interrupted by the inclement weather of the winter. It was resumed in the spring of 1881, and was directed to supplement existing information on the northern rivers, the American, Bear, Yuba, and Feather, the basins of which contain the largest deposits of gravel and the heaviest operations in mining.

The State Engineer Department had made examinations and partial surveys, particularly on the Yuba and Bear Rivers, the results of which had been published or were otherwise accessible to this office. These examinations were continued by Mr. Manson during the season of 1881, and are comprised in the following general description:

1. Reconnaissance of the cañon of Bear River on foot, from the plains to Dutch Flat, 40 miles.
2. An instrumental survey of Bear River below the entrance of mining detritus for a distance of 23½ miles.
3. Examination and profiles of the restraining dam on Bear River, and the reservoir space above.
4. A survey of the restraining dam on the Yuba, and careful examination into its condition.
5. Instrumental survey of the site for a dam at the Narrows on the Yuba, below the mouth of Deer Creek.
6. Reconnaissance of the cañon of the North Fork of the Yuba and tributaries, on foot, 55 or 60 miles.
7. Reconnaissance on foot of cañon of North Fork of the American from Dutch Flat to Folsom, 45 miles.
8. Reconnaissance on foot of the Middle Fork of the American from Ford's Bar to the mouth, 18 miles.
9. Reconnaissance on foot of South Fork of the American from Chili Bridge to mouth, 40 miles, and of tributaries of South and Middle Forks, 60 miles.
10. The condition and prospects of mining on the South Fork and south side of Middle Fork of the American.
11. Reconnaissance of the Feather River from Marysville to Oroville, 36 miles.
12. Cross-sections of channel and valley of Feather River, aggregating 10 miles, embracing 12 miles of river below Oroville.
13. Reconnaissance on foot of the Feather River and its tributaries from upper limit of mining to Oroville, 125 miles.
14. General inquiry into condition and prospects of mining on the Feather and its tributaries.

These examinations and surveys, taken together with those conducted by the State Engineer Department, cover the field quite fully, as to the main points of the inquiry. The examinations on the American were interrupted before completion by rain, which makes the cañons of the rivers impracticable for travel.

Mr. Manson's reports covering the results of these operations will be found appended.

Attention has been given to the determination of the quantity of gravel remaining to be mined in the several basins in cases where it admits of estimate.

The sub-reports hereinbefore mentioned contain much information on this point. A separate appendix contains estimates of workable volumes remaining to be mined by hydraulic process, tributary to the North Fork of the American and to the Bear rivers. It is not claimed that these estimates are more than approximations.

The largest deposit of gravel lies on the San Juan Ridge, between the middle and south forks of the Yuba. This field is known to be large enough to afford employment during many years for the appliances now in action (which are the most extensive in the whole mining region). It was, therefore, thought unadvisable to attempt to obtain more definite information in regard to this volume, the determination of which of necessity does not admit of more than a very rude approximation.

The quantities of water used in the basins tributary to the Sacramento River, in 1880, returned by county assessors, published as an appendix in the report of January 10, 1881, in connection with the duty of water now approximately determined, afford the means of estimating the yearly output of the mines in the Sacramento Basin.

The same kind of information is afforded in Lieutenant Payson's report for the mines south of the American.

Information collected in past years, either by this office or by the State Engineer Department, as to the condition of rivers and lands, and the changes which have taken place, or are now in progress, and the tendencies that appear to exist will be referred to in this report, which, with the hope of giving a more comprehensive view of the problem in hand, will allude to such facts as are accessible in illustration of the magnitude of mining investments and appliances, and the results of these in the production of the precious metals.

DESCRIPTION OF MINING FIELD.

The navigable waters of California affected by hydraulic mining consist of the bays of Suisun, San Pablo, and San Francisco, forming the great estuary of California, and of the rivers, the Sacramento, the San Joaquin, and the Feather.

The Sacramento River rises in the north and flows in a southerly direction through the great valley, flanked on the east by the Sierra Nevada, and on the west by the coast range. The Feather is a tributary of the Sacramento.

The San Joaquin has its source in the south and flows in a northwesterly direction through the valley, uniting with the Sacramento at the upper or eastern end of Suisun Bay. The strait of Carquinez connects Suisun Bay with San Pablo Bay, which opens into San Francisco Bay, and, taken as a whole, these separate bays and rivers afford a continuous channel, connecting with the Pacific Ocean through the Golden Gate.

The auriferous drift deposits which are worked by the hydraulic process lie on the western slope of the Sierra, in a belt 40 or 50 miles wide, extending from the plains or edge of the valley to altitudes of 4,000 or 5,000 feet.

The length of this deposit, measured in a northwesterly direction, parallel to the crest of the Sierra, is about 150 miles, and extends from the Merced River on the south to Chico Creek in the north, with some exceptionally placed deposits lying both north and south of these limits.

It may be remarked that in addition there are, on the Klamath and Trinity, one of its branches, quite important places, which are now worked. The detritus is lodged in the rivers, which are neither navigable or tributaries of navigable rivers, so that this separate mining district is not thought to come within the limits of this investigation. The Klamath empties into the Pacific Ocean a few miles south of the northern boundary of California.

The tributaries of the San Joaquin, coming from the Sierra Nevada, and affected by mining, either past or present, are the Merced, the Tuolumne, the Stanislaus, the Calaveras, the Mokelumne, and the Cosumnes. Each of these rivers has small tributaries, which, for the sake of clearness, need not be mentioned by name, but which are to be understood as being included in the designation of the larger tributaries.

The Feather and American are the principal tributaries of the Sacramento, which drain the mining districts.

The Feather is a large river draining 3,400 square miles, and includes as its tributaries the Yuba, with its three forks, and the Bear, which rivers are noted as the seat of the principal hydraulic mining operations of California.

The Sacramento and San Joaquin rivers near their mouths flow through a delta of considerable extent, the surface of which is below the level of flood waters.

The connecting channels surround a number of islands. The soil is extremely fertile, and great efforts have been made, thus far with limited success, to reclaim the land. Insecurity in foundations and the absence of a proper material for making levees, have been the chief difficulties in the way of complete reclamation.

On the east side of the Sacramento, close to the river, between the American and Feather, is a basin the level of which is a number of feet below the banks of the main river. This basin is overflowed in every freshet.

A similar and more extensive basin lies in the angle between the Sacramento and Feather rivers, extending from the Marysville Butte to the mouth of the Feather, a distance of about 30 miles. This basin is also overflowed at high stages of the river. Its great area and capacity for storage give it an important influence in determining the flood flow of the river.

These features are here mentioned that a future reference to them may be intelligible.

Several small streams—the principal of which is Auburn Ravine—carrying mining detritus, and natural tributaries of the Sacramento River, do not reach it directly, but discharge into the basin between the American and Feather.

The drainage from the Spring Valley Mine, on the waters of Butte Creek, enters into the Sutter Basin between the Sacramento and Feather rivers, and, therefore, does not reach the Sacramento directly.

The lower portions of the Cosumnes, Mokelumne, and Calaveras, all tributaries of the San Joaquin, lie in the delta lands, which receive a part of the mining detritus of these streams, and to this extent relieve the San Joaquin from injury.

ANCIENT DRAINAGE.

The existing drainage system of the auriferous gravel belt is geologically recent. Mining operations have unveiled an older system, lying higher and oblique to the existing drainage, obliterated during the Pliocene period, by deposits of sand, gravel, clay, and bowlders with gold intermingled.

The ancient drainage lines are the loci of modern hydraulic mining operations. Subsequent to the destruction of the ancient channels the whole country was covered by a flow of lava and kindred substances, which yet remains in many places a complete bar to effective mining; when hydraulic mining is practicable the basalt has disappeared or is replaced by volcanic ashes.

The existing rivers flow through the mountains in cañons cut down to depths varying from 1,000 to 2,500 feet below the ridges which bound them on either side.

The portions of the old drainage lines which remain are on these ridges, and therefore are at considerable elevations above the present river beds. This feature is generally true of the northern portion of the auriferous belt, while in the southern portion the levels of the two systems do not present such marked differences. A considerable elevation above existing river beds is indispensable in hydraulic mining in order to give a good clearance of the tailings. This feature is presented most favorably in the mines on the Yuba, and it is one of the reasons for the great development of the hydraulic industry in that part of the country.

The ancient river beds are again distinguished from the modern by greater width and steeper slopes.

In position they are generally oblique to the existing drainage system. So far as mere surface indications are concerned, the old system was completely obliterated. Occupying in the aggregate many square miles in area, the whole surface was filled to the rim rocks with gravel, and over these to a depth often of many hundred feet by a plain of eruptive material extended from the summit of the Sierra to the valley.

The capping of lava has since been lost in many places. In others it is thin, exposing the top surface of the gravel.

Under these circumstances it has been impossible to trace out the old drainage system, and it is only by comparison of altitudes and directions of the small portions that have been uncovered by the miner, and tracings here and there of the rim rock, that any inferences can be drawn as to the courses of the ancient rivers.

In consequence there are many opinions as to the directions of the drainage.

The modern rivers cutting across the old drainage lines swept the gravel and gold down their own beds, and thus formed the bars which so richly repaid the labors of the early miners. Deposits of this kind, whether in the beds or on the banks, or in gulches at small elevations above the beds, are workable without much aid from capital. Water can be secured by storage in reservoirs close at hand or be brought by short canals, the construction of which is practicable by the labors of the miners themselves. These river or placer deposits were worked out in a few years, and it was only as they were being exhausted that attention was directed to the higher and larger deposits in the old river beds.

The extent of these deposits is not known. A great part of them is hidden under the lava cap which covers the flanks of the Sierra with more or less continuity. Definite information exists only where the mines have been opened to a considerable extent. When this is the case, the depth of the gravel deposit has been found to be as much as 600 feet. This is however an unusual depth. One hundred and fifty or 200 feet depth is frequently found. While the deposit is known among the miners as gravel, it is not by any means all gravel, nor is the deposit homogeneous as a rule in any mine or in any district.

The vertical section of a mine may show sand on top, with pipe clay, then gravel, first fine and afterward coarse, generally white, often colored; and in the bottom a large proportion of bowlders, sometimes tons in weight.

Stratification on planes either horizontal or inclined may be observed in some cases.

The variety in the components and in their arrangement forbids, in a sketch of this kind, any other conclusion than the general one, that the material becomes coarser and heavier as you descend from the surface to the bed-rock.

The accepted theory now is that these river beds were filled by detritus brought down by their own currents. If this be true, it would follow that the lighter materials, the only ones transportable in the slight slopes of the river when nearly extinct, should be found on top.

The different grades of materials are not, however, clearly segregated in their places of deposit. Sand is found everywhere in the vertical section, mixed in geater or less abundance with coarser material.

It often happens that the components are found to be cemented, by iron-oxides and silica in solution, into conglomerates that need powder or stamp-mills to disintegrate them.

Gold is generally found everywhere in the gravel, but not in equal proportions. The gravel on top is generally poor, and the best pay is near the bed-rock. In cases where the pay is concentrated in a streak 4 or 6 feet thick near the bed-rock, it may be secured by stopping out this stratum, leaving the upper mass undisturbed. This is drift mining. Generally, however, the pay is not concentrated, but diffused throughout the gravel in increasing proportion from the top to the bottom.

The only way to get the gold in this general case is by the hydraulic process.

THE HYDRAULIC MINING INDUSTRY.

The first engineering problem presented in an attempt to work deposits lying at high altitudes is to introduce a sufficient supply of water at an adequate height.

The head of a canal fulfilling the necessary conditions must be placed on the river where its bed is some hundreds of feet higher than the gravel to be worked. The canal must be built for many miles on the steep flanks of the ridges which extend from the main vertebra of the mountains toward the plains.

When canals were built, it was found in many cases that the supplying rivers did not in the low stages afford an adequate amount of water. This deficiency was remedied by the construction of reservoirs still higher in the mountains, which retained in storage enough water collected in the season of abundance to supplement the supply during the period of inadequate river flow.

In order to apply the water supply to hydraulic mining, a conveyance of detritus from the mines to the dumps has to be provided. This, in the general case, requires the construction of one or more tunnels in bed-rock, the upper end under the lowest point of the gravel to be worked, and the lower end opening if possible into a deep cañon, with room for holding the accumulations of one or more seasons.

These sluice tunnels form one of the most expensive adjuncts to hydraulic mining. The longest and most costly single tunnel is that for the North Bloomingfield mine, which is nearly 8,000 feet in length, its cost being $500,000.

A permanent and sufficient water supply, a good bank of gravel, and a suitable outfall are the conditions for success.

The extent and boldness of the engineering operations just referred to are calculated to excite surprise and admiration.

Tables follow which give statistics as to the reservoirs, canals, and tunnels in a part of the mining field.

The first two tables refer to the principal hydraulic mines of the State.

It will appear from table on pages 20 and 21 that there are quite 6,000 miles of mining ditches in California. Quartz and placer mines, as well as hydraulic mines, are supplied by them.

Table of reservoirs on the Yuba, Bear, Feather, and American rivers, constructed for mining purposes.

Name of company.	Capacity.	Authority.
	Cubic feet.	
North Bloomfield	1,050,000,000	Hamilton Smith, jr.
Milton Company	650,000,000	Do.
Eureka Lake	1,130,000,000	Do.
South Yuba	1,800,000,000	Do.
Omega and Blue Point	300,000,000	Do.
Spring Valley	300,000,000	Do.
California	600,000,000	Do.
El Dorado	1,070,000,000	Do.
Other small reservoirs on the Feather, Yuba, and American rivers	700,000,000	Do.
Total storage	7,600,000,000	

Incomplete statistics of mining ditches in California, from Mint Report, 1881.

Name.	Length.	Capacity.	Grade by feet.	Cost.	Dimensions in feet.		
					Top.	Bottom.	Depth.
	Miles.	*Inches.*	*Per mile.*				
North Bloomfield, including reservoirs	157	3,200	12 to 16	$708,841	8½	5	3½
Milton, including reservoirs	80	3,000	12 to 25	391,579	6	4	3½
Eureka Lake and Yuba ditches	163	5,800		723,342			
South Yuba ditches	123	7,000	8 to 13		6		4 to 5
Smartsville ditches	113	5,000	9	1,000,000	8	5	4
Spring Valley and Cherokee	52	2,000			5		3½
Hendricks	46½		6 to 12	136,150	5		2
La Grange	20	2,700	7 to 8	500,000	9	6	4
Blue Tent	32	1,800	10	150,000	8	6	4

NOTE.—The length of Smartsville ditches is taken from reports on the mines, by Professor Pompelly.

Hydraulic mining, as it is understood in California, is that process by which a natural bank is excavated by a jet of water and conveyed by the same water through the sluices to the dumps. Water does all the work; manual labor is needless in a perfect bank; when bowlders are found too large to pass through the sluice they are sometimes blasted into smaller pieces suitable for the sluices.

Where the bank is cemented or contains masses of pipe clay it is shattered by charges of powder. The scale of blasting corresponds to the other features of this kind of mining, 30,000 or 40,000 pounds of powder being on occasions exploded to break up a bank. The method is similar to that used at Lime Point in 1868.

In a certain sense all mining is hydraulic. Water is indispensable for the separation of gold in all the processes of mining.

But before the introduction of existing appliances water was used for this purpose only. Now water under pressure excavates, water transports the detritus, and with the aid of quicksilver collects the gold.

The very moderate amount of human labor required is the secret of the cheapness of this kind of mining.

The hydraulic method dates from about 1855. The first efforts in using water under pressure were in rubber or canvas hose, with nozzles of an inch or less diameter. Now nozzles vary from 4 to 9 inches, and pressures are as high as 400 feet.

An 8-inch nozzle at North Bloomfield discharges 185,000 cubic feet in an hour, the velocity being 150 feet per second.

This is the culminating instance of this kind of force. There are, however, frequent instances of one-half or one-third of this hose power being applied.

The excavating power of a force of this extent on a bank of gravel is enormous, and in general unless the gravel is very heavy or cemented is much in excess of the transporting power. The latter depends on the grade of the sluice, so that really the latter factor becomes in great part the measure of the quantity of gravel that can be handled, for it is not desirable to excavate more gravel than can be sluiced away.

Grades of sluices vary from mine to mine. The topography generally determines the fall of sluices. It is desirable to have a grade of 4 or 5 per cent., very often the grade is necessarily much lower, and in some cases 8 or 9 per cent.

The following table, taken from a paper entitled Hydraulic Mining in California, by Augustus J. Bowie, mining engineer, volume vi, Transactions of the American Institute of Mining Engineers, gives the grades of the tunnels of the principal mines on the Yuba River.

Name of mine or tunnel.	Locality.	Length of tunnel.	Average grade of tunnel.	Reported cost.
			Feet per 100	
Boston	Wolsey's Flat	1,600	7¼	$40,000
North Bloomfield	Humbug Cañon	8,000	4½	500,000
Farrel	Columbia Hill	2,200	3½	Not complete
English mine	Badger Hill	1,400	7	
American	Below San Juan	3,900	6¼	140,000
Manzanita	Sweetland	1,740	4¼	62,000
Sweetland Creek	do	2,200	4½	90,000
Bed-Rock	Below Sweetland	2,600	5¼	
French Corral	French Corral	3,500	4½	165,000
Babb	Timbuctoo	1,200	3.80	
Pactolus	do	1,700	4.16	
Rose's Bar	do	1,600	4.16	
Blue Gravel	Succor Flat	1,100	4.50	
Pittsburgh	do	900	4.16	
Blue Point	do	2,250	4.16	
Enterprise	do	1,200	4.16	
Deer Creek	Mooney's Flat	2,200	3.40	

If the inclination of the sluice be increased, the quantity of material carried off by a given amount of water will increase more rapidly. This fact is well understood; the law has not yet been fully developed. Sometimes it is claimed that the quantity worked will vary with the square of the inclination, that is, if the inclination be doubled the quantity worked will be four-fold.

The quantity which an inch of water will handle is its duty.

The duty depends on the kind of material. In light gravel, 10 or more yards may be moved to an inch of water taken to be 2,250 cubic feet. In the heavy material of the bed-rock, the same water and grades may not move one-eighth or one-tenth of the former volume.

The differences in material, grades, and other circumstances give for each mine a particular duty, and thus far have prevented the deduction of the law of change in quantities moved, due to changes in inclination.

In particular instances water in sluices of an average grade, the material being of moderate quality carried 10 or 11 per cent. of gravel in weight, otherwise expressed, 2,250 cubic feet of water carried 14,000 pounds of gravel, which in volume is about 4 cubic yards. It may be remarked that when the material is heavy it is carried on the bottom of the sluice, and as a rule only the lightest material is in suspension.

So the duty varies in the same mine from the top to the bottom, and from mine to mine. A mean duty adopted by the State engineer is given with the next table, which is assumed as the basis for this report.

The quantities of water used in 1880 in the Sacramento Basin were returned by the county assessor and published as an appendix to the report of January 10, 1881.

This report not being complete is supplemented by information collected by the State Engineer Department.

Summarized the table is as follows:

Name of stream.	Quantity of water used in mining and discharged into bed of river in twenty-four hours.	State engineer's estimate of duty per inch.	Amount moved.
	Inches.	*Cubic yds.*	*Cubic yds.*
Table Mountain or Dry Creek	833, 250	3½	2, 916, 375
Butte Creek	24, 000	3	84, 000
Feather River	1, 259, 363	3½	4, 407, 770
Yuba River	5, 458, 171	3½	19, 103, 598
Bear River	1, 117, 082	3	3, 351, 246
Dry Creek, No. 2	44, 229	3	132, 687
American River	1, 914, 500	4½	8, 615, 250
Total	10, 650, 505	....	38, 610, 926

The amount of material discharged, as found from this computation, and the amount of water used are both less than previous estimates. The quantity of water used in 1880 was about 870,000,000 cubic yards, of which 281,500,000 were stored in reservoirs, as will appear by the preceding table.

The following table gives information collected by Lieutenant Payson in regard to rivers south of the American:

Estimate of material moved annually.

River.	Mine.	Ditch.	Water used, twenty-four hours.	Cubic yards moved per twenty-four hours per inch.	Total number cubic yards moved.	Summary.	Remarks.
			Inches			*Cubic yds.*	
Cosumnes	Hill Top	American and Sacramento	456,000	2½	1,140,000	....	Much heavy material stored in ravine.
	Various placers	Jordan	48,000	....	40,000	1,180,000	Part of water used for power.
Dry Creek	Irish Hill	American and Sacramento	162,000	2½	405,000	405,000	Little now reaches any river.
Mule Creek	Various small placers	Johnson's	38,000	1	38,000	38,000	
Sutter Creek	Various placers and hydraulic	Amador Canal	54,750	1	54,750	....	
	Volcano hydraulic	Volcano	365,000	2½	912,500	....	Not now working dump in bed of dry creek.
	Various placers	Johnson's	38,000	1	38,000	1,005,250	
Jackson Creek	Various placers and hydraulic, M	Amador Canal Company	127,750	1	127,750	....	
	Near Buena Vista, at head of Jackson Creek.	Dougherty	43,400	1	43,400	171,150	
Mokelumne	Near Campo Seco, Camache and Stockton Ridge.	Mokelumne	61,000	2	122,000	....	Bulk of heavy material stored in ravines. Part of water used for power.
	Railroad Flat, head South Fork	Clark's	45,000	2	90,000	....	
	Near Lancha Plana and Camache	Murray & Dougherty's	118,500	....	60,000	272,000	
Calaveras	Near Jenny Lind	Salt Spring Valley Reservation and Union.	365,000	2	730,000	....	Formerly in main stream. Heavy material now mostly stored.
	Chile Gulch and Jesu Maria Fork of Calaveras.	Mokelumne	200,750	2½	501,875	....	
	Juniper, at Dogtown, San Domingo Creek.	Union	365,000	2½	912,500	....	In bed of streams.
	Near Mokelumne Hill	Cook Brothers	45,000	2	90,000	2,234,375	
Stanislaus	Near Knight's Ferry	(small)	38,720	2	77,440	77,440	In main rivers.
Tuolumne	La Grange and Patricksville	La Grange	812,500	2½	2,031,250	2,031,250	
	Total at present	....	3,384,370	....	7,414,465	....	

Quartz and drift mining contribute a considerable quantity of detritus, none of which can be expected to remain where discharged from the mines. The product of the quartz mill is impalpable sand. The drift miner leaves the bowlders in the mine and brings out only the gravel.

The Chinese mine quite extensively in the beds of the rivers in low stages. They take the water out of the bed in a flume and sink shafts or run drifts in the gravel. While this makes no additional contribution to the amount of gravel in the river bed, it disturbs the equilibrium and facilitates the movement down stream.

There are no means of estimating the amount of detritus due to these causes, although they contribute in a sensible degree to the evils due to mining.

Professor Price estimates that in the year 1881 two thousand five hundred and forty-six stamps in quartz mills contributed to the drainage lines of the State 1,500,000 tons, otherwise expressed as 1,000,000 cubic yards of detritus.

Drift mines are numerous, but there are no statistics of the detritus furnished by them. The Bald Mountain drift mine is reported as contributing 106,160 cubic yards in a year.

There are a large number of quartz mines in the State. Lieutenant Payson found south of the American River in 1880 eight hundred and forty-two stamps running, producing an estimated yearly amount of 567,575 cubic yards of tailings. There is no report in regard to the number in operation north of the American.

There are also a large number of drift mines in Sierra and Plumas counties, the production of which either in gold or detritus is not ascertained.*

THE ECONOMIC ASPECT OF MINING.

It is stated in the testimony in the case of the State of California *versus* The Gold Run Mining Company that the capital invested in mining in California is about $160,000,000, of which $100,000,000 is in gravel mining. This appears to be a generalized opinion, based upon a partial knowledge of investments. It is not based on detailed information, and is not claimed to be more than an approximation. So far as it applies to gravel mining, the amount is probably in excess. Perhaps it is quite as well for the purposes of this report to be able to say that the invested capital is large as to be able to give the specific amount. This kind of information for a majority of mining properties is quite out of the question.

The natural secrecy of business operations and the varied and complicated circumstances of the different properties forbid any attempts in this direction.

The assessed valuations might be a guide, but these are now much depressed by litigation, present and prospective. In the cases of the principal hydraulic properties held by incorporated companies information can be obtained.

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*Those who desire to obtain a full account of the hydraulic system are referred to a paper on the subject by Augustus J. Bowie, jr., published in Volume VI, Transactions of the American Institute of Mining Engineers.

The geological relations of the gravel will be found fully described in a work by Prof. J. D. Whitney, entitled the Auriferous Gravels of the Sierra Nevada of California, printed for the Museum of Comparative Zoology at Havard College.

These works have been consulted in the preparation of this report, as may be noticed by the references.

The following list is believed to be quite accurate, as in most cases the information is taken from the books of the companies:

Excelsior Company, of Smartsville	$2,857,166 55
North Bloomfield and Milton	4,079,321 62
Gold Run Company	433,335 00
Blue Tent	755,000 00
El Dorado Deep Gravel	1,008,611 60
Eureka Lake (approximate)	2,500,000 00
South Yuba Company	2,000,000 00
Spring Valley Company	2,000,000 00
La Grange (about)	650,000 00
	$16,283,434 77

This list includes a number of the principal hydraulic mines of the State, but there is a much larger number of smaller properties not included, in reference to which no information is at hand.

A considerable amount of capital is understood to be invested in mining ground acquired for mining purposes.

The most important single group of mines not included in the list is that at and about Dutch Flat and tailing into Bear River.

Referring to the table next to come, it will be found that there are seventeen counties in California in which mining is a principal industry and in some it is the basis for all industries, in the sense that if it did not exist, the population would mainly disappear.

So far as hydraulic mining is concerned Nevada is the county which produces the most gold, two-thirds of its production being credited to hydraulic mining.

Trinity County production is believed to be nearly all due to earth washing, and the same is true of Shasta and Sierra Counties. Mono County production comes from vein-mining.

Attention is invited to the column of remarks in the table, which describes the resources of each county in a general way, and discriminates partially between the different forms of mining.

It may be said that the belt of country on the flank of the Sierra Nevada, from the Merced River to Chico, is interested to such an extent in mining interests of one kind or another, that its abandonment would change the condition from prosperity to extreme depression, which might be expected to last until new resources are developed.

The table may be used for the purpose of reaching an approximate relation between the production from earth-washings and that due to the quartz industry. The items are not segregated in sufficient detail to enable one to establish an exact relation, but it cannot be far from one of equality.

The table is made from returns to the mint and other official departments, and so far as the production of the precious metals is concerned is apparently incomplete, and perhaps necessarily so.

The production stated for the fiscal year ending June 30, 1880, is $15,148,505. It appears from Wells, Fargo & Co.'s estimate that the production of California in 1879 was $18,190,973, and for 1880 $18,276,166. The production for the fiscal year ending June 30, 1880, embracing half of each of the calendar years of 1879 and 1880, may well be assumed to be the mean production of those two years, which is $18,238,567, an amount $3,098,062 in excess of the tabular statement.

It may be supposed that the production from gravel-washing forms a greater proportion of this unreported sum than the quartz production. This supposition is justified by the fact that there are a great number of small properties of this kind, the aggregate production of which is considerable, which would be more likely to be unreported than the quartz-industry, which generally involves the investment of considerable capital.

Giving weight to this consideration, it appears fair to say that earth-washings may be credited with an annual production of nearly $10,000,000, the quartz-industry being credited with the remainder.

Tabular statement showing condition of mining in California for the fiscal year ending June 30, 1880.

[Compiled from Mint Bureau Returns, United States Census, and State Reports.]

Counties.	Number of quartz mills.	Number of mining ditches.	Miles of mining ditches.	White population in mining counties.	Chinese population in mining counties.	Gold bullion produced.	Silver bullion produced.	Total production.	Remarks.
Alpine	3			589	17	17, 113	24, 146	41, 259	Silver and gold bearing veins.
Amador	12	7	300	10, 271	1, 115	1, 495, 053	1, 953	1, 497, 006	Principally from quartz on Mother Lode; three hundred and seventy-five stamps running.
Butte	8		390	14, 937	(*)	430, 501	1, 247	431, 748	Principally from deep places by hydraulic mining, and agricultural county.
Calaveras	47	26	525	8, 057	1, 037	320, 865	643	321, 508	Production divided between quartz and shallow placers.
Colusa						4, 830	78	4, 908	Shallow placers; agricultural county.
Del Norte		22	87			215, 403	300	215, 703	Beach sands and shallow placers.
El Dorado	26	5	500	9, 197	1, 483	389, 383	208	389, 591	One third from quartz, balance from drift claims and hydraulic.
Fresno	1					143, 433		143, 433	From quartz by arastras; agricultural county.
Humboldt						153, 940	80	154, 020	Beach sands and shallow placers; agricultural county.
Inyo	5	1	6	2, 928	90	48, 648	173, 916	222, 564	Silver-bearing veins and argentiferous lead ores; principally extracted by smelting.
Kern	4					94, 214	390	94, 604	Gold-bearing quartz veins; agricultural county.
Lassen	2	3	7			25, 900		25, 900	Gold-bearing veins at Hayden Hill; agricultural and grazing county.
Los Angeles		4	21			7, 700	66, 300	74, 000	Shallow placers; agricultural county.
Mendocino						733	125	858	Black sands; lumber and agricultural county.
Modoc						10, 000		10, 000	Supposed to be from adjoining counties; grazing and agriculture.
Mono	10	5	40	7, 140		2, 407, 236	582, 905	2, 990, 141	Gold and silver veins at Bodie.
Mariposa	27		107	3, 642	697	150, 017	1, 300	151, 317	Principally from quartz mining.
Merced						17, 515		17, 515	From quartz by arastras; agricultural and grazing county.
Nevada	17	217	824	16, 820	(*)	2, 702, 362	70, 144	2, 772, 506	About two-thirds by hydraulic; balance quartz.
Placer	10	22	358	12, 030	2, 196	835, 433	640	836, 073	About four-fifths from hydraulic and drift claims; balance quartz.
Plumas	15	34	700	5, 312	(*)	857, 124	181	857, 305	About one-half quartz; balance hydraulic.
Shasta	4	28	650	8, 156	1, 336	140, 455	117, 907	258 362	Principally hydraulic mining.
Stanislaus		1	15			73, 271		73, 271	Principally from shallow placers; agricultural county.
San Diego	2					81, 558		81, 558	Shallow placers and gold-bearing quartz; agricultural and grazing county.
Sacramento		2	200			342, 514		342, 514	From shallow placers; agricultural county.
Siskiyou	5	6	250	7, 049	1, 561	434, 612	251	434, 863	Three-fifths from shallow placers; balance quartz.
Sierra	22	55	366	5, 373	1, 250	974, 332	576	974, 908	One-third low-grade quartz; balance drift claims.
Tehama						1, 500		1, 500	Shallow placers; agricultural and grazing county.

Tuolumne	20	14	190	7,043	805	461,861	1,071	462,932	About one-half from quartz; balance from placers.
Tulare	3	1	....	....	....	1,125	526	1,651	About two-thirds from vein mining; agricultural county.
Trinity	......	25	400	3,052	(*)	326,693	142	326,835	Principally river and shallow placers; quartz by arastras.
Ventura	......	......	....	....	....	354	....	354	Quartz by arastras; grazing county.
Yuba	1	6	100	9,121	(*)	937,360	438	937,798	Gold from hydraulic mines; county has large agricultural interests.
Totals	253	484	6,036	130,717	11,587	14,103,038	1,045,467	15,148,505	

* No returns.

The production of the San Juan ridge in the year 1881 was $1,705,019, of which $144,351.97 was from drift mining.

The North Bloomfield, Milton, and American Companies, which produced nearly one-half of the whole hydraulic output, were idle four of the best months of the year under an injunction of Judge Keyser. It is thought that but for the injunction the production of the ridge would have been $2,000,000.

The production from washings is nearly all due to deep placer mining, including in this term both hydraulic and drift mining, but no attempt is here made to apportion the production to its various sources.

The information at hand leads to the conclusion that the annual production of hydraulic mining does not exceed, if it equals, two-thirds of the gross amount credited to earth washings.

On the other hand it is proper to remark that somewhat different views are held, as will be observed from the following quotation from Prof. J. D. Whitney, page 368, Auriferous Gravels:

> At the beginning of the present decennium it [the gold production] was probably about $20,000,000 in value, and since that time has slowly and irregularly decreased, the present production being about $18,000,000. Considerably the larger portion of this comes from the hydraulic and tunnel mines, chiefly from the former. The best authorities estimate the present yield from this source at from $12,000,000 to $14,000,000.

While these results are to some extent indefinite, they are nevertheless sufficient to limit error of judgment within bounds compatible with the purposes of this report.

The following tables are compiled by Hamilton Smith, jr. They are believed to be the most reliable existing estimate of the production of the precious metals in California.

Products of precious metals in California, 1848 *to December* 31, 1881.

[The figures from 1848 to 1857, inclusive, are based upon estimates made by Mr. Louis A. Garnett, late manager San Francisco Refinery. The estimates from 1858 to 1870, inclusive, are made by Professor Raymond, Official Report as Mining Commissioner, 1874, page 543; from 1871 to December 31, 1881, from the official estimates of Mr. John J. Valentine, superintendent of Wells, Fargo & Co.]

1848—1870, INCLUSIVE.

1848	$15,000,000	Brought forward	$648,100,000
1849		1860	45,000,000
1850	45,000,000	1861	40,000,000
1851	75,000,000	1862	34,700,000
1852	85,000,000	1863	30,000,000
1853	75,000,000	1864	26,600,000
1854	65,000,000	1865	28,500,000
1855	65,500,000	1866	25,500,000
1856	65,000,000	1867	25,000,000
1857	57,600,000	1868	22,000,000
1858	50,000,000	1869	22,500,000
1859	50,000,000	1870	25,000,000
Carry forward	648,100,000	Total	972,900,000

1871.—DECEMBER 31, 1881, INCLUSIVE.

Year.	Gold.			Silver.			Total.
	Carried by express.	Carried by other conveyances.	Total.	Carried by express.	Base bullion and ore.	Total.	
1871	$16, 167, 484	$3, 279, 870	$19, 447, 354	$231, 870	....	$231, 870	$19, 679, 224
1872	16, 493, 922	1, 649, 392	18, 143, 314	233, 668	$673, 116	906, 784	19, 050, 098
1873	15, 709, 956	1, 570, 995	17, 280, 951	264, 771	480, 000	744, 771	18, 025, 722
1874	16, 015, 568	1, 601, 556	17, 617, 124	967, 857	1, 715, 550	2, 683, 407	20, 300, 531
1875	14, 842, 010	1, 484, 201	16, 326, 211	387, 768	1, 039, 172	1, 426, 940	17, 753, 151
1876	14, 635, 963	1, 463, 596	16, 099, 559	796, 308	1, 719, 940	2, 516, 248	18, 615, 807
1877	14, 512, 123	725, 606	15, 237, 729	1, 202, 751	1, 734, 236	2, 936, 987	18, 174, 716
1878	16, 482, 389	824, 119	17, 306, 508	809, 431	804 522	1, 613, 953	18, 920, 461
1879	16, 348, 730	817, 436	17, 166, 166	739, 440	285, 367	1, 024, 807	18, 190, 973
1880	16, 900, 745	845. 000	17, 745, 745	378, 567	151, 854	530, 421	18, 276, 166
1881, 1st six mos.	8, 969, 878	448, 500	9, 418, 378	298, 264	(?)	298, 264	9, 716, 642
1881, 2d six mos.	7, 379, 338	368, 960	7, 748, 298	250, 318	305, 421	555, 739	8, 304, 037
Total	174 458, 106	15, 079, 231	189, 537, 337	6, 561, 013	8, 909, 178	15, 470, 191	205, 007, 528

The diminished product of gold for the last six months of 1881 was largely due to stoppage of several important mines by injunction.

RECAPITULATION.

	Gold.	Silver.
1848-1857, Garnett	$548, 100, 000	
1858-1870, Raymond	424, 800, 000	
1871-December 31, 1881, Valentine	189, 537, 337	$15, 470, 191
	1, 162, 437, 337	15, 470, 191

Being an aggregate of about $1,178,000,000 since California belonged to the United States.

Much the greater portion has been derived from gravel found in ancient river beds or eroded from them and afterwards deposited in modern streams or on their banks.

It is altogether to be supposed hundreds of millions yet remain untouched and buried in the pliocene gravel.

This branch of the subject is here closed with the following extract from an article of Mr. Skidmore, in the Mint report of 1880, which gives information in regard to the yield from gravel:

The following tabular statement of the average yield of auriferous gravel, worked on a large scale by the hydraulic method, has been compiled from the returns of companies who have acquired extensive and exclusive water rights and large areas of ground, embracing the principal enterprises included in the table on page —:

Name of company.	Average height of bank.	Yield per cubic yard.
	Feet.	*Cents.*
Smartsville claims, Yuba County	112	19½
Blue Tent, Nevada County	180	15
North Bloomfield, Nevada County	180 to 260	4 to 6½
Gold Run, Placer County	200	4½
Columbia Hill, Milton County	100	4½
La Grange, Stanislaus County	18 to 100	2½ to 15½
Patricksville, Stanislaus County	40 to 60	4½ to 18½
Dardanelles, Placer County	150	13

But the profits of hydraulic mining do not depend so much upon the contents per cubic yard as upon the facility and economy with which the auriferous material may be moved, cost of water, means of outlet, &c. It is within the personal knowledge of the writer that a claim near Iowa Hill, Placer County, yielded cost of outfit and a fair profit in the season of 1879, when the product was only three cents per cubic yard. In this case the owner possessed a water-right and ditch.

With a view to the presentation of some statistics of the operations of hydraulic companies, with a record of production less than the average, I have selected the data of several claims in Stanislaus County, California. The figures are compiled from a paper on hydraulic mining in California, by Aug. J. Bowie, jr., mining engineer, which will be found in the Transactions of the American Institute of Mining Engineers for 1879.

The period covers the operations of two seasons.

Name of claim.	Average height of bank.	Pressure of water.	Cubic yards washed.	Cubic yards of gravel moved per miner's inch.	Yield per miner's inch water.	Yield per cubic yard.
	Feet.	*Feet.*			*Cents.*	*Cents.*
French Hill claim	30	50 to 70	676,968	1.08	14	13
Light claim	45	60	683,244	1.80	12	6⅔
Chesnan claim	28	70	284,932	1.37	23	16
Johnson	30	80	196,632	1.76	8	4
Licard	90	90	155,347	2.89	37	13
For a corresponding period the North Bloomfield of Nevada County, showed the following results	180 to 260	....	4,104,790	4.5	23	5½

Name of claim.	Cost of water per cubic yard.	Cost of labor material, &c., per cubic yard.	Total cost per cubic yard.	Total expenses.	Total yield.
	Cents.	*Cents.*	*Cents.*		
French Hill claim	1.	5	6	$42,655 83	$90,186 19
Light claim	.006	3	3⅝	25,962 82	45,444 65
Chesnan claim	.008	4	4⅘	15,923 71	47,781 73
Johnson	.006	3	3⅝	7,466 60	9,148 27
Licard	.004	3½	3 9/10	6,205 40	20,197 07
For a corresponding period the North Bloomfield, of Nevada County, showed the following results	.0755	2¼	3	147,912 58	267,007 50

The examples above cited have been selected exclusively from the record of companies who have washed gravel of low grade by hydraulic method with a steady profit. The average yield per cubic yard on the above exhibit would be 7¼ cents. In the case of the claims in Stanislaus County, if we take 7¼ cents per cubic yard as the average yield, and 45 feet as the height of bank, each acre of gravel washed would yield $5,263.50. In Weaver Basin, Trinity County, the yield has been from $8,000 to $12,000 per acre, where the height of the bank has varied from 30 to 50 feet. These examples are quoted for the purpose of showing the minimum rates of profitable operations where the depth of the gravel is less than 100 feet.

The average of the deep washings on the ancient channel claims, where the banks are more than 100 feet in height, would be a little over 10 cents per cubic yard, if we make the estimate from the basis of the returns of the past five years.

At the North Bloomfield mine, Nevada County, the yield has not averaged 10 cents per cubic yard. The yield of this company per miner's inch of twenty-four hours for the past ten years has varied from 13½ to 27½ cents, but this has been from top dirt, the bed-rock bench not being reached.

But we should not assume from the foregoing statement of the operations of companies hydraulicking low-grade dirt that the richer ground of the deep placers is exhausted.

A recent examination of the yield of the Paragon claim, Placer County, California, by F. Von Leight, mining engineer, shows the following results for six seasons (from 1874 to 1879), by the hydraulic method only:

Total production for period	$243,075 87
Dividends paid	119,670 14
Average yield per miner's inch, calculated on a basis of twenty-four hours' inch, under 6-inch pressure	2 54

In this case the lower stratum was washed and the bed-rock stripped. The highest yield per inch was in the season of 1874 and 1875, when $4.04 per inch was realized; the lowest was in the season of 1878-'79, when 86¼ cents per inch was realized. The largest yield of any season was that of 1875-'76—$90.04 or $3.43 per inch. The company are also engaged in drifting, but the yield and value of ground from that source will be noticed under the head of drift-mining.

The system of valuation of ground per cubic yard has long been in disuse in California, by reason of the disparity of conditions of a hydraulic bank, both in respect to its material (whether composed largely of pipe-clay or gravel) and its depth. Thus, several successive hydraulic benches in deep placers may yield, from grass roots to a depth of 100 feet or more, from 5 cents to 20 cents per cubic yard, while the lower or bed-rock stratum will yield from $2 to $6 per cubic yard. In many cases surveys are not made, and the returns are the results of "guessing." The highest returns of the past season by the hydraulic method, where measurement was made, is stated, on the authority of Mr. James Arnott, of Brandy City, Sierra County, to be $1.50 per cubic yard. In this case the bank was 24 feet in height, and the yield included the lower stratum and the bed rock. The product per miner's inch has come to be accepted as the standard of value of hydraulic ground.

Table showing the yield of gravel per cubic yard of hydraulic mines in California, from Mint report, 1880.

Name of claim.	Location.	Cents yield per cubic yard.	Authority.
American Company	Sebastopol, Nevada County	24.0	Hamilton Smith, jr.
Blue Tent	Nevada County	15.0	R. W. Raymond.
Blue Point (1870)	Smartsville, Yuba County	123.0	Hamilton Smith, jr.
Gold Run (1870)	Placer County	04.8	William H. Pette.
Dardanelles and Aro	Forest Hill, Placer County	13.1	Joseph McGillivray.
McCarty's Diggins	Columbia Hill, Nevada County	43.3	J. D. Hague.
Smartsville Mine	Sucker Flat, Yuba County	19.5	Amos Boman.
Union Gravel Mine	Empire Hill	15.0	do.
Pactolus Gravel Mine	Yuba County	20.8	do.
Blue Gravel Mine	do	63.0	do.
Pittsburgh	do	41.0	do.
Pactolus	do	44.0	William Ashburner and J. D. Hague.
North Bloomfield	do	12.0 to 16.3	Hamilton Smith, jr.
Spring Valley	Cherokee, Butte County	28.0	R. H. Stretch.
French Corral	Nevada County	33.4 to 47.4	Hamilton Smith, jr.
Manzanita	do	27.4 to 33.3	do.

The above table extends over a peried of ten years' operations, but the yield is not averaged, as it has varied from year to year.

Reference may here be made to the civil and social aspects of the controversy between mining and other interests as developed by the litigation which has been in progress for several years, with a prospect of a long continuance.

A very important suit is now in progress before a State court of justice. It is entitled the State of California versus the Gold Run Mining Company. It has occupied the attention of the court for two months, and enlisted the services of some of the ablest counsel in the State. Many of the witnesses are among the ablest and best informed citizens of the State. No case could be watched with more interest by all persons concerned with the prosperity of the State.

The issue is the right of miners to discharge detritus into beds of streams. A decision can hardly be expected for several months.

In 1878 the case of Keyes versus Little York Gold and Water Company and others, was tried in the tenth judicial district of California.

The decree enjoined the defendants in this language, namely, that they—

> Be and they are each of them hereby perpetually enjoined and restrained from using the bed of Bear River, or the beds of any or either of its branches, tributaries, ravines, or gulches, as a place of deposit, or as a dump or place of discharge for the

tailings or debris of their said mines or mining claims or either of them, and especially from using said beds of said streams or either of them as a place of deposit of the tailings from those mining claims known as the Empire, Christmas Hill, etc. * * *; and they and each of said defendants are further hereby perpetually restrained and prohibited from fouling and corrupting the water of Bear River, and its branches, tributaries, streams, ravines, and gulches, with the tailings or debris from their said mines, or either of them.

Among the defendants enjoined were a number of parties engaged in mining by the drifting process.

The language of the decree so far as it relates to fouling or corrupting the waters of the rivers, applies to quartz-mining as well as to all other descriptions of mining. In this case none of the defendants were vein-miners.

The decree was overruled by the supreme court of the State on a technical point which did not affect the merits of the case.

The distinctions between different kinds of mining so far as they relate to the beds of water-courses as places of deposit, are distinctions of degree and not of principle. As practiced at present they all foul the waters of streams. The impalpable sand products of quartz mines are borne by currents with the greatest facility and are deposited in places where currents are reduced to little or nothing.

The detritus from drift mines differs in quality from that of the hydraulic mines in that the former is composed mainly of gravel of ordinary sizes mixed with sand, while the latter contains in addition considerable amounts of large stones and of pipe-clay.

To what extent mining can be prosecuted under the conditions expressed in this decree, remains to be seen. Quartz tailings may certainly in some cases, perhaps in many, be impounded in reservoirs near the mills in a way to conform to the conditions. In drift mines the difficulty will be considerably greater owing to the large volume of detritus, while the existence of hydraulic mining is quite inconsistent with the terms of the decree.

NATURAL DENUDATION.

A comparison of artificial denudation in mining with that due to natural agencies, if it could be fully made, would be a profitable and interesting step in this investigation.

Unfortunately, the data for the determination of natural denudation in the Sacramento basin do not exist.

A few observations of the quantities of sediment carried by the Sacramento River have been made, but they are hardly in sufficient numbers to form a basis for calculation. As they exist, the portion due to mining and the portion due to natural agencies cannot be segregated.

The physical characteristics of the Sacramento basin affecting the question are condensed from the report of the State engineer, 1880.

The total area of the Sacramento basin is 24,708 square miles, of which 4,709 square miles are plains of the main valley. The rainfall in the valley may be averaged at 18 or 20 inches.

The Sierra Nevada flanks the valley on the east, with an area of 8,298 square miles, the height of range varying from 7,000 to 11,000 feet. In seasons of ordinarily heavy rainfall this region receives from 24 to 102 inches of rain.

The Coast Range flanks the valley on the west, with an area of 3,075 square miles. The Range has considerably less height than the Sierra, and the rainfall is much lighter.

At the northern end of the plains lies a mountainous district 5,616 square miles in area, within which lies Mount Shasta, 14,400 feet in height. The rainfall here is larger than in any other part of the district, ranging from 30 to 110 inches.

The area drained by Pit River is stated approximately as 2,950 square miles. The rainfall is unknown, but less than on the Sierra.

Three-fourths of the area is thus shown to be mountainous, and the greater part of the mountain area is subject to very considerable rainfall, which perhaps may be averaged for the whole area of mountains at 35 or 40 inches, and for the area of the basin at about 30 inches.

The fall of rain is confined to four or five months, and the greater part usually falls in two months. The precipitation in the higher portions of the Sierra is in the form of snow, which is melted in the months of April, May, and June.

The Sierras were originally covered with timber. Along the line of the railroad the hills have been stripped; a young growth is taking its place. Along the whole range there is a large destruction of timber, used for mining and other purposes. Much of it finds its way when manufactured to the valley and other markets in Arizona, being floated from the mountains by V flumes.

The Coast Range is comparatively without timber.

The mean slope of the basin is, by reason of the great mean altitude, very much in excess of that of most rivers and particularly of large rivers.

In volume III of the transactions of the Geological Society of Glasgow, Professor Geikie states the times required by natural agencies, to remove an average thickness of one foot of rock in each of several drainage basins, as determined by the amount of sediment carried by the rivers which drain them. They are as follows:

	Years.
Danube basin	6,846
Mississippi basin	6,000
Nith basin	4,723
Ganges basin	2,358
Rhone basin	1,528
Hoang Ho basin	1,464
Po basin	729

Applying the Mississippi rate of one foot of rock removed in 6,000 years to the Sacramento basin, which has an area of 24,708 square miles, it will be found that in one year, 4,250,000 cubic yards of rock will be removed. Converting this volume of specific gravity of 2.5 into sediment having specific gravity of 1.9 it becomes 5,592,110 cubic yards.

If we apply the rate of the Po, the yearly denudation of the Sacramento basin would be in rock 34,300,000 cubic yards, or in sediment 43,000,000. The Rhone rate would give 21,950,000 cubic yards of sediment, and the Ganges 13,230,000 cubic yards, as the natural denudation of the Sacramento basin.

This comparison would be more satisfactory if we could know that the sediment assumed to be carried by the rivers had been carefully obtained. In the case of the Mississippi, the amount carried in suspension was the subject of more than two years careful observation, the details of which are to be found in the Physics and Hydraulics of the Mississippi River, page 136.

The only statement in regard to the sediment carried by the Po, that is accessible to the writer, is that Lombardini assumes the ratio of sediment to water in volume to be $\frac{1}{300}$, this rate having been determined by Ludini.

The extent of the observations upon which the statement is based is unknown; the same is more or less true of the other rivers mentioned in the table.

In the case of the Mississippi, the amount carried on the bottom and not suspended does not result from observation.

In area and topography there is a noticeable likeness between the basins of the Po and the Sacramento. The areas are 24,700 for the Sacramento and 26,800 for the Po.

The Sierra Nevada and the Coast Range correspond to the Alps and the Apennines, both in the fact that they respectively flank the rivers through a great part of their courses, and also in that the Sierra approaches the Alps in altitudes, and resembles them in heavy deposits of snow; while the Coast Range, like the Apennines, delivers its floods with rapidity, and is comparatively free of snow. The Sierra is distinguished from the Alps by greater breadth, owing to which the proportion of mountain to plain is considerably greater in the Sacramento than in the Po.

The lacustrine rivers of the Alps have, however, no adequate counterparts in the Sierra.

In point of rainfall the basin of the Po probably surpasses the Sacramento. The slopes of the two basins have a fair correspondence.

The denudation of timber on the Sierra is in all probability considerably less than that of the Alps.

The average rainfall in the basin of the Mississippi cannot differ much from that of the Sacremento, although the mode of occurrence is altogether different, the downfall in the Sacramento being confined to a few months in the year. The mean slope of the Sacramento basin is very much in excess of that of the Mississippi.

This discussion is altogether of too general a nature to lead to a conclusion more definite than this, namely, that the rate of natural denudation in the basin of the Sacramento is in all probability in excess of that of the Mississippi, and probably less than that attributed to the Po.

But whatever may prove to be the position of the Sacramento between these limits of 5,592,110 cubic yards of sediment, representing the Mississippi rate, and 43,000,000 cubic yards representing the Po rate, we cannot, in any event, help being impressed by the comparison which shows the relations existing between the respective powers of natural forces acting in nature's way, and a part of the same agencies controlled and directed by man, both applied in degradation of the earth's surface.

The comparison is more striking when, instead of being applied to the whole area of the Sacramento basin, it is confined to the limits of the field of the Yuba, Bear, and American rivers, where mining exists on the greatest scale.

The area of the basins of these tributaries is 3,520 square miles, which is one-seventh of the whole area of the Sacramento basin.

Under any rate that we can be justified in assuming for natural denudation, even that of the Po, it will easily be seen that the annual mining denudation in these basins is several times in excess of that due to natural causes.

To place this in a more specific light, we may recall that the mining detritus annually placed in the three rivers is quite 31,000,000 cubic yards; while the Po rate of denudation applied to the area of the basins would afford little more than 6,000,000 cubic yards per year.

These general considerations are calculated to convey to the minds of those familiar with the natural circumstances of rivers as clear a conception of the magnitude of the problem as would be afforded by a study of its details.

They explain the accumulations in the river beds, by making it evident that mining operations contribute more material per year than the floods of that year are able to carry.

It also becomes plain that if the mining were to cease now, the floods, being able to transport considerably more material than that due to natural erosion, would then be in a condition to attack deposits in the beds, which are comparatively safe so long as the floods are overloaded as they now are.

CHANGES IN NAVIGABLE WATERS.

The navigable waters are the channels of the Great Bay, and the Feather, the Sacramento, and San Joaquin rivers.

So far as the rivers are concerned, we are not in possession of charts of old date, which compared with recent maps would afford an accurate record of the changes that have occurred in the past generation.

Nevertheless, the partial records that exist, and well-established facts developed by inquiry and by comparison of statements made by those who by reason of occupation or residence must be supposed to have knowledge of certain facts, are sufficient to enable a fair general comparison to be made of the present and former conditions of the Sacramento River below the entrance into it of mining detritus.

As for the San Joaquin River, no evidence is known to exist showing any change of importance in its channels.

A gauge has been observed at the city of Sacramento with more or less continuity, since and including the year 1849, which was the date of the great influx of people into California.

The gauge readings of the low stage of the river are here given to include the year 1881:

	Feet.
1849, low-water reading	zero.
1869......do	2.9
1874......do	4.9
1875......do	4.5
1876......do	7.1
1877......do	5.3
1878......do	5.5
1879......do	5.8
1880......do	7.4
1881......do	6.5

It may be observed that the low-water plane was raised 2.9 feet in the twenty years succeeding the beginning of mining, and that the next ten years, from 1869 to 1879, doubled the rise of the plane.

The table shows a continuous rise, with some anomalies, which may in part at least be accounted for by the different volumes of the river in its low stages. The difference in volume may be accounted for by difference in rainfall, and also by the influence due to the amount of water contributed from the storage reservoirs of mining companies.

A local change in the slope of the river may also be due to variations in the amount of detritus deposited in the Sacramento by the American, which joins the main river at Sacramento.

Notwithstanding these variations, the conclusion is plain that the low-water plane at Sacramento has been raised about 6 feet since 1849.

As a consequence of the elevation of the bed, the tidal influence which in 1849 extended at least as high as the mouth of the Feather, 25 miles above Sacramento, and was quite 2 feet at Sacramento, is now no longer noticeable above Heacock Shoals, 9 miles below Sacramento.

The tide within the past thirty years rose on these shoals as much as 3 feet.

Corroborative evidence of the rise of the bed is afforded at the Russian Embarcadero, 10 miles below Sacramento, which in old times was 3 feet out of the water in the low stage. In 1878, it was found to be 1½ feet under water, showing a rise of surface of about 4½ feet.

This is confirmed again by the level of the low-water of 1852, which was fixed at Greene's Ferry, 3 miles above Courtland, by the level at which the branches of a tree were cut off in that year for the accommodation of the ferry boat. This level is 4 feet below low water of 1878.

Confirmation of like character is afforded by trustworthy circumstances needless to record, occurring at the Hog's Back and at Ida Island.

The State engineer gives the changes of level in 1880 as 5 to 5½ feet at Sacramento; mouth of Feather, 3 or 4 feet; head of Steamboat Slough, 1½ to 2½ feet. (Page 31, report 1880.)

The rise of the low-water plane indicates filling not so much in the pools of the river as on the shoals. All of the shoals below Sacramento have been bored, and samples have been collected under the direction of this office. The deposits are found to be chiefly mining detritus.

We may fairly assume that the filling in the pools has at least kept pace with the rising in the low-water plane. This assumption, which is much within probability, and within facts so far as they are known, would make a general filling of the bed between the Feather and Sacramento, a distance of 25 miles, to be 5 feet, and for the 60 miles below Sacramento an average of about 3 feet, to which is to be added the deposit in Steamboat Slough.

The State engineer compared a survey of 1854, made by direction of the town council, by the city surveyor, of a portion of the river 2 miles in length in front of the town of Sacramento, with the condition of the river in 1879.

The maximum filling was 25 feet and the average 15 feet. (State Engineer's report 1880, page 31.)

Specific information of this kind for the river as a whole is lacking, therefore no means exist for obtaining an estimate in any detail of the aggregate deposits in the Sacramento River made during the last thirty years. They can only be generally inferred from known facts.

Twenty-five miles below Sacramento the river divides into two delta channels, which unite below, the intermediate distance by two channels being 18 miles by Old River, and 12 miles by Steamboat Slough.

In the earlier days of navigation and until six or eight years ago, Steamboat Slough was the channel used by all boats and vessels. It is now obstructed by shoals and at low tide carries only about 4 feet, so that its navigation is now for the most part abandoned.

Old River is now the navigable channel. The depth on the bars of the river at low water does not appear to have been diminished to a great extent, but the expulsion of tidal influence in whole or in part has resulted in a decrease of effective depth. As the slope of the river increases, it is plain that the low-water discharge will afford a constantly diminishing depth. The decrease on the bars produced to this time has been masked by the absence of tide. As the scouring influence of the tide is diminished, the tendency to deposit is increased.

Above the city of Sacramento as far as the Feather, although the deposits have been large, the effective depth appears not to have suffered to any great extent, if at all. The slope in this reach has probably not been much changed. It would not be changed if we supposed the elevation of the surface at the mouth of the Feather to be just equal to that at the mouth of the Sacramento. This may be the case, for although the Feather is the outlet of a more entensive mining field, the main Sacramento into which it empties is at and above this point free of mining detritus.

For this reason the minor output of the American may be able to maintain at Sacramento a rise of bed equal to that produced by the Feather.

However this may be, the best accessible testimony indicates that there has been no change of effective depth between Sacramento and the mouth of the Feather worthy of notice.

The width, however, of portions of this stretch of the river has been considerably diminished.

Large deposits of fine mining detritus 10 or more feet above low water, and covered with willow growths, now form the banks for considerable distances, the old banks in rear being indicated by the growth of heavy timber. This is a regulation of the river-bed by the influences of nature, which could not have occurred except for the loads of sediment in the river.

The Feather River low-water level at Marysville, the head of navigation, has been raised about 15 feet. The rise in level at the mouth, 30 miles below, is given by State engineer, already quoted, 3 or 4 feet.

The description of the mouth of the Feather, given by the Wilkes exploring expedition, indicates more filling at the mouth.

Investigations made by this office in comparing present with former depths on Fish Slough bar and the middle ground, both being in the Sacramento River above the mouth of the Feather, prove quite satisfactorily that in 1878 the filling at the mouth of the Feather was fully 5 feet. At present it can be no less.

Taking 15 feet at Marysville, and 5 feet at the mouth, the difference, 10 feet, is to be added to the old fall. This increases the slope of the Feather in its navigable part 4 inches to the mile. This increase has impaired the depth of water and the practicability of navigation to a considerable extent.

Applying to the navigable portion of the Feather the rule adopted for the minimum deposit in the Sacramento, namely, that the average filling is equal to the elevation of the plane of low water, we will have for the 30 miles, from Marysville to the mouth, an average depth of 10 feet over the bed of the river. This estimate is thought to be here, as in the Sacramento, considerably below the fact.

As a consequence of these changes a higher flood line and greater exposure to overflow now exists for all riparian lands on both these rivers. This is an element of considerable loss to the country, but its description and discussion do not come within the limits of this investigation.

The steepening of the slopes when they are low, as they necessarily are in navigable streams, is in the direction of the fulfillment of the condition essential to enable the river to carry the material delivered to it.

The steady increase of elevation of the low-water plane at Sacramento indicates that the relation now existing between slopes and sediments is not that of stable equilibrium, and for the present we must look continued increase of slope.

If we suppose the weight of sediment presented to the river for transportation to be increased, an increased rate of steepening in slopes must be anticipated.

The elevation of the bed of the river is not accompanied by an equal rise in the level of the banks. The level of the beds approaches more and more the level of the bank. In the cases of the Yuba and Bear, non-navigable streams yet to be described, the level of the beds has risen from a depth a number of feet below the banks to an elevation of several feet above the banks.

These instances may be taken to illustrate the ultimate condition of the Sacramento and Feather Rivers, under a continuance of the influences to which they are now subjected. The abandonment of existing channels is a consequence to be apprehended.

The information that has been obtained in regard to the channels of the bay, results from a study in obedience to a resolution of the House of Representatives, of the 12th of June, 1880, which called for a report upon the causes tending to diminish the tidal area of the bay and the commercial value of the harbor of San Francisco. The report made in obedience to this resolution was published by the House of Representatives, Forty-sixth Congress, third session, Ex. Doc. No. 93.

The main facts are here reproduced:

1. A careful comparison of the charts of San Francisco entrance bar, made in 1855 and 1873, shows that the bar had suffered no injury in that interval.

2. A comparison of surveys of the ships' channel of a portion of San Pablo Bay, made in 1855, 1863, 1878, shows that between 1855 and 1863, no deposits of much importance were made in the channels.

The surveys of 1863 and 1878 are distinguished by a deposit of 76,025,000 cubic yards made in the interval. The depth of deposit averaged over the area of comparison 24¼ square miles, would be 3.1 feet. The deposit, however, did not occur in the shape of a layer of uniform thickness. It occurs mainly on the flanks of the channel, and has the effect to narrow the channel without affecting to any noticeable extent the ruling depth. The mean reduction in width of channel between the 18-foot contours obtained by comparison of six cross-sections, is 2,820 feet, which is 22 per cent. of the mean width of 1855.

This comparison includes only the channel. The shoal-water areas were necessarily excluded from comparison, owing to the fact that no survey of them has been made since 1855.

3. A comparison of maps of 3½ miles on the Sacramento near its mouth and 1 mile at the mouth of the San Joaquin, shows a deposit of 2,000,000 cubic yards in the Sacramento, and 500,000 in the San Joaquin between 1867 and 1878.

The comparison of charts of Suisun Bay made in 1867 and 1878, shows an extension in area of the shoals, which have not yet been measured in a detailed way.

A comparison of charts of Carquinez Straits during different dates indicates the formation of large deposits in recent years.

No opportunity has offered as yet for the investigation of the origin of the deposits in the bays. It would be possible to determine by a sufficient number of samples taken from each locality, whether the deposits are mainly due to either of the two great sources of erosion, the artificial due to mining or the natural.

It is to be presumed that both causes are represented in these effects.

DEPOSITS OF DETRITUS IN TRIBUTARIES OF NAVIGABLE WATERS.

The Yuba and Bear tributaries of the Feather, and the American, a branch of Sacramento, present to inspection large deposits of detritus in their beds and on adjoining alluvial lands.

These are in places of temporary lodgment, where they are left by one flood and removed in greater or less degree by the succeeding one. Each movement carries a quota into the navigable streams and maintains the features of these rivers that have been described.

The loci of these deposits are determined by the circumstances of the case, among which may be mentioned the character of the detritus as to size and weight, the volume of flood waters and the natural grades of the river beds.

Differences of circumstances correspond to widely different localities of deposit.

The cañons of the three forks of the Yuba are distinguished by heavy natural grades. The mines on the Yuba afford a large supply of fine material, and the flood discharge is large; consequently we find the upper cañons quite free from deposit, which begins to be important only where the three forks unite to form the main Yuba.

On the Bear a great proportion of heavy material is deposited near the head of the river, about and above Dutch Flat. The river does not head in the high Sierra, and, therefore, it has not the same flood characteristics as the Yuba. We find a very large and increasing deposit in the vicinity of the mines themselves.

In 1879 Professor Pettee found the bed of the bear, at the crossing between Dutch Flat and Little York, to be 97 feet higher than in 1870, and that in the same interval Steep Hollow, between Little York and and You Bet, had risen 136 feet. (Volume II, page 425, Auriferous Gravels, by Prof. J. D. Whitney.)

The best information available leads to the opinion that the Bear River here is filled 150 feet in depth; Steep Hollow, 250 feet; and the Greenhorn, at the crossing of Nevada and Dutch Flat Road, 200 feet deep.

Where the detritus consists, in part, of heavy cobbles or larger stones, it is supposed to remain where deposited, or at least to be moved slowly. It thus forms a barrier which serves to impound above it a mass of gravel, which otherwise would have traveled farther down stream.

The steep grade of the Bear River bed below the Dutch Flat dump may be taken to be that which the floods in this stream require to give motion to the heavy material there deposited.

The average grade from Dutch Flat, for 10 miles below, to Nevada Railroad bridge is 55 feet to the mile, being about 30 feet at the lower end, and presumably 80 feet at the upper. Over all this distance the cañon is filled and graded—cobbles and large stones above, with diminished sizes below.

With the exception of about 11 miles, the river bed is filled from Dutch Flat to the mouth. Below the Nevada Railroad bridge, wherever the grades are in the neighborhood of 25 and 30 feet to the mile, there are large deposits; and where the grade is 40 feet, the amount is noticeably decreased, while in the 11 miles already mentioned as free from deposits, the grade varies between 80 and 140 feet to the mile.

On any such grades as have been mentioned, the deposits are mainly of gravel and cobbles, with comparatively little sand. The great reservoirs of sand lie at the exit of the river from the foothills and on the plains below, where the deposit is widened in resemblance to, but not to the same extent as on the Yuba, with grades of from 8 to 5 feet to the mile.

Attempts have been made by various parties to estimate the volumes of these deposits. Such attempts must be regarded in the light of conjectures. The circumstances do not permit estimates in the true sense to be made, except with great outlay of time and money. In the case of Keyes *vs.* Little York Gold Washing and Water Company evidence was given by several experts, placing the amount of deposits in the Bear River, above the plains, as 86,000,000 cubic yards, and below the foothills to the mouth 36,000,000 cubic yards; total, 122,000,000. This was in 1878.

Similar estimates by Mr. Manson, reported to the State engineer, give the estimated deposits, in 1879, on the Yuba above the foothills as 48,462,100 cubic yards, the great bulk in 8 or 10 miles; and below, 23,284,000; a total of 71,746,100 cubic yards. In the light of later information, it seems probable that this estimate is altogether too low, the deposits in small tributaries not having been taken into account, and the amount in the lower river having been much underestimated. The actual amount is ~~not~~ capable of being ascertained, and the statements are given merely for purposes of illustration.

At its escape from the mountains, where the foot-hills recede and give width to the plain, the Yuba spreads out its load of sand and gravel over a plain of 15,000 to 16,000 acres, which has risen until it now stands above the level of the adjoining country on either side.

This plain has a slope of about 10 feet to the mile, varying above and below this limit as you ascend or descend the river bed, being 15 feet at the foot-hills and 5 feet at Marysville, 10 miles below. The sizes of material have some correspondence to the grades.

Ascending the stream one passes to a continually increasing average size of material. While it is nearly all sand below, above it becomes nearly all gravel, with, however, considerable admixtures of different sizes everywhere.

This eruption from the mountains has destroyed thousands of acres of alluvial land. The State engineer, in 1880, estimated that 15,220 acres had been seriously injured by these deposits from the Yuba.

On the Yuba the great deposits of gravel are found on a grade of 30 feet to 20 feet to the mile. The sands predominate greatly in slopes of 10 feet and below.

On grades greater than 40 feet to the mile the cañons are generally quite clear of material, unless it be stones of considerable size.

The forks which have been alluded to as quite free from deposits have grades generally exceeding 50 feet to the mile.

Mr. Manson supplies the following information in reference to the American River:

> The American, a tributary to the Sacramento, presents the following general features and characteristics:
>
> Its water-shed extends to the summit of the Sierra Nevada, and is drained by three principal forks. The northern one of these is the recipient of a large amount of detritus and is much filled up, down to its junction with the Middle Fork. The depth of this deposit is variously estimated; the maximum depth is probably as much as 100 feet. The volume is, as in other instances, a matter of conjecture, but probably does not fall far short of 20,000,000 or 25,000,000 of cubic yards.
>
> The grades upon which this material has found lodgment vary from 46 feet per mile in the upper reaches, where coarse material is lodged, to 29 feet per mile where finer material has been carried. This latter grade is found in a portion of the cañon some 20 miles in length. In this there is economical storage.
>
> After the North and Middle forks join the grade is about 22 feet per mile; the large volume of flood-water sweeps all material out of the cañon of the American, only the coarsest finding lodgment in protected places, and equalizing the inequalities in the original grades. These grades, although lighter than those above, upon which material has lodged, have a larger volume of flood-water passing down them, and hence no deposits of moment have occurred.
>
> The Middle Fork is not so much filled as the North Fork, as hydraulic mining is not so extensive upon it.
>
> The grades in its lower reaches are somewhat less than upon the North Fork, and the

cañon is of greater lateral dimensions. Although this portion of the river is suitable for storage, such use is entirely prohibited by the existence of valuable mines in and near the bed of the river, whose destruction would be caused by the storage of *débris* in this portion of the river. The upper portions of this stream have not been examined for more than 8 or 10 miles farther; here the grades are about 45 feet per mile, and the cañon narrow. Storage is available here for the coarsest material from above.

The South Fork is practically clear of *débris;* that which has been discharged into it has been of a different character from the bulk of that discharged into the rivers farther north.

The application of the hydraulic process to the ancient river gravel is limited, owing to the lava covering the greater portions of the ancient channels; those portions which were exposed under the edges of this lava cap have been nearly exhausted. Decomposed slate, carrying quartz veins, is extensively mined by the hydraulic process, but the hardness of this material limits the quantity moved in a given time, and the shape of the particles of slate prevents them from being easily transported; hence a larger proportion of the waste products remains on the dumps and in the small tributaries. The finer detritus from the mines in the basin of the South Fork forms an excellent soil, as is shown by the deposits intentionally caused by parties owning land upon which this material can be diverted; its desirable quality could be easily predicated, from the fact that there is a great deal of the surface soil washed.

From the mouth of the cañon to the Sacramento River there have been some 6,000 acres of land covered, and 25 or 30 miles of river-bed, from 200 to 400 feet wide, raised from 5 to 30 feet.

The deposits in the Lower American do not admit of being restrained in the bed of the stream by means that are considered practicable under present circumstances. The amount cannot be specifically stated, but from what precedes it may be conjectured to be twenty or more million yards.

The deposits in the upper cañons of the Feather appear from Mr. Manson's account to be very limited. At and below Oroville, however, they become very extensive, in positions where it is difficult if not impossible to exercise control over them. They are a constant injury to the navigable waters below. Being beyond the range of practicable restraints they are foreign to the purposes of this report.

Lieutenant Payson estimates the volume of deposits in the bed of the Cosumnes River to be 6,000,000 cubic yards, and the maximum depth of filling to be 20 feet.

Reference to his report will show that the same state of affairs exists in all the rivers south of the Cosumnes to the Merced, the degree, however, being very much less than that shown to exist on the Yuba, Bear, and American.

GRAVEL WORKABLE BY HYDRAULIC PROCESS.

The quantity of auriferous gravel now remaining on the flanks of the Sierra Nevada is practically unlimited. If it were all workable its exhaustion would task the energies of miners for many generations. No practical end could be served by an attempt to estimate the aggregate mass.

For several good reasons only a comparatively small portion of the whole can be regarded as workable under existing conditions.

The workable quantity in several basins is in a certain sense subject to estimate between limits in an approximate way. Such an estimate is very desirable in order to give a basis for an opinion as to the extent, cost, and duration of any system which may be adopted for the purpose of remedying evils consequent upon mining.

The estimates that follow are thought to be sufficient for the present purpose, and any considerable errors that may be found in them can be corrected in the future by more accurate information.

All gravel which will pay a profit under the hydraulic process may be regarded as workable.

Under the most favorable circumstances it is Professor Whitney's opinion that gravel yielding 4¾ cents per cubic yard may be worked at a profit. Abundance and cheapness of water are essential, as well as favorable outfall. (Page 371, Auriferous Gravels.)

This, however, must be understood to apply only to the light top gravel, which is readily moved. The yield must be much greater to give a profit in the lower portions where bowlders and cemented gravel are frequently encountered.

The hydraulic process may be unprofitable, because the gravel does not contain sufficient gold, or because it is overlaid with too much or too hard a capping, or because the outfall is insufficient, or because the supply of water is not at hand.

If the gold is found in a pay streak close to the bed rock, it may be more profitable to stope out the pay gravel than to wash the whole superincumbent mass by hydraulic process.

Generally speaking, working is a question of richness. If there is no outfall the hydraulic process cannot be applied. If the gravel is rich enough, and there is an outfall, capital can supply all that is required to apply the hydraulic process.

Keeping this in view, the approximate estimates of gravel tributary to the Bear River and to the North Fork of the American, contained in appendix 3, will be intelligible. It will be observed that the material in each of the mines is classified particularly as to size, as cobbles, gravel, sand, lava, ashes, &c. The object of this classification is to afford a basis for calculating amount to be stored, it being generally assumed that the cobbles and bowlders will not be carried far from the mines.

It is thought to be safer under our present knowledge, or rather want of knowledge, to regard the whole mass as requiring storage, including both the portion which by reason of its fineness is incapable of storage and the heavier portion, which, perhaps, may never reach the reservoirs. We thus make compensation for any error in the underestimation of material.

The estimates for the Bear River and the North Fork of the American are based upon an inspection of each mine, but not on instrumental measurements, which the funds available did not permit to be made.

The American.—It appears that the territory tributary to the North Fork of the American contains of workable gravel 75,190,010 cubic yards.

In the first-named district are the Gold Run and Iowa Hill Mines. In illustration of differences that throw more or less discredit on all estimates of this kind, which, at best, are rude approximations, reference is made to Professor Pettee's conclusions in regard to the Gold Run Mine in 1870. (Page 147, Auriferous Gravels.)

He estimates the amount washed off south of the railroad at 43,000,000, and the amount remaining at 86,000,000 cubic yards; and adding other claims not yet touched, the gross amount to be mined becomes 125,000,000 cubic yards.

In the testimony recently given in the case now under trial at Sacramento, The State of California *vs.* The Gold Run Mining Company, the State engineer gives the amount washed off to date as 52,440,000 cubic yards. Other witnesses estimate the amount remaining in the Gold Run Mine variously from 18,000,000 to 22,000,000 yards.

In 1870 Mr. Goodyear estimated gravel to be mined at Iowa Hill at 26,000,000 yards. (Page 119, Auriferous Gravels.)

Mr. Larson's estimate in 1881 is 6,388,800 cubic yards, which allows for nearly 20,000,000 washed between 1870 and 1881.

On the ridge south of the American and between it and the Cosumnes, Mr. Manson reports that practicable hydraulic mining is about exhausted. The gravel deposit from Placerville to Sportsman's Hall, 14 miles in length, is lava-capped to depths of 50 to several hundred feet, and the mines are now worked up to the edge of the lava.

The lava is regarded as a bar to further use of the hydraulic process. There is, however, a large field for drift-mining.

In 1870 Mr. Goodyear estimated the quantity remaining subject to the hydraulic process near Placerville, at 50,000,000 cubic yards. (Page 120, Auriferous Gravels.)

Mr. Manson supplies the following information in regard to the gravel deposits on the Georgetown divide, which lies between the South and Middle Forks of the American.

Gravel deposits worked on the Georgetown divide, are—

(1.) Volcanoville.
(2.) Mount Gregory.
(3.) Rubicon.
(4.) Mount Hope.
(5.) Mount Ross.
(6.) Jones Hill.

All discharge directly or indirectly into the Middle Fork.

Of those *Mounts Hope* and *Ross* have not been worked for four years although belonging to a company having an abundance of water. This deposit is lava-capped.

Jones Hill has exhausted its claim on the south side of the deposit, and the water has been turned to the north side and preparations made for opening work; claim to have from 400 to 500 inches for nine months in the year. Deposit limited, and lava-capped.

The amount on the Forest Hill divide tributary to the Middle Fork of the American has not been ascertained, even approximately. The yearly contribution of detritus is stated by Mr. Manson to be about 2,500,000 cubic yards, and includes that from the south side of the Middle Fork.

Yuba.—The deposit on the San Juan Ridge, between the South and Middle Yuba, is, for several reasons, the most important in the State. It is much the largest deposit, and it lies very favorably for working, the beds of the ancient rivers being elevated some hundreds of feet above the beds of modern streams.

The floods in the Yuba may be relied on to carry away the gravel, which is generally light in character.

The canal and reservoir systems are more developed than in any other portion of the State and the yield of gold is greater than that derived from any other equal area.

An approximate estimate of the quantity of workable gravel on this ridge was made in 1876 by James G. Hague. The quotation is from a printed report on the water and gravel mining properties belonging to the Eureka Lake and Yuba Canal Company:

> The linear extent of the gravel channel and its branches on this ridge is about 25 miles. Deducting liberally for the portion already worked and for that too deeply covered by lava to be available for hydraulic mining, there remain probably not less than 14 miles of channel available for washing, from which only a comparatively small portion of the top gravel has been removed. Below San Juan the gravel body has a surface width of over 1,000 feet, and is, say, 140 feet deep. From Badger Hill to Bloomfield it is for the greater portion very much wider and deeper. At Columbia

Hill its surface width varies from 3,000 or 4,000 to 8,000 feet, and it is from 300 to 600 feet deep. The gravel at Lake City is probably 300 or 400 feet deep. At North Bloomfield it is opened to the bed-rock, showing a depth of more than 300 feet. Roughly estimating the average width of the remaining gravel range at 400 yards, and after allowing for the portion worked off, placing its average depth at 70 yards, the sum is an average of, say, 50,000,000 yards per mile, or for 14 miles, say, 700,000,000 yards.

Allowing for the amount washed since 1876, 100,000,000 yards, there remain 600,000,000 to be removed.

The working of the lower lying deposits at Columbia Hill will, however, require the driving of a tunnel between 2 and 3 miles in length. It may be regarded as doubtful whether under existing circumstances a work of this magnitude will be undertaken.

The terms used in the description indicate that it is only approximate, but, while this is the case, no one has attempted a correction, and in the treatise on the Auriferous Gravels, by Prof. J. D. Whitney, Mr. Hague's estimate is adopted.

The best information in regard to the extensive mining property of the Excelsior Water and Mining Company, at Smartsville, is derived from reports made in 1879. This property consists of 525 acres of mining ground, which contained, according to Professor Pumpelly, 76,500,000 cubic yards of gravel. Mr. Janin's estimate was 75,000,000 cubic yards. This is expected to produce per cubic yard 25 cents by Mr. Janin's estimate, and 34 cents according to Professor Pumpelly. The lower of these estimates being fulfilled will make the working very profitable.

There are other deposits about Smartsville, in regard to which no definite information has been obtained.

There are also deposits in the basin of the North Fork of the Yuba, which are noticed in Mr. Manson's appended report, the cubical contents of which we have not the means of stating. They are, however, of much smaller dimensions than those already enumerated.

Seven hundred millions of cubic yards may be assumed to represent the amount of gravel, workable by hydraulic process, tributary to the Yuba.

The Bear River.—By the estimate contained in appendix 3, the quantity of gravel workable by the hydraulic process is, in the Bear and tributaries, in round terms, 50,000,000 cubic yards, which is a comparatively small proportion of the whole amount.

The choking of the beds of the river and the tributaries, which are the outfalls of the mines, explains the small amount of the estimate. The *débris* from the Dutch Flat Mines is unusually heavy, and forms barriers in the river beds which impound a large amount of detritus above.

In the Quaker Hill mines the lower gravel can only, under present circumstances, be worked by drifting, there being no outfall for sluices. The top gravel is stated (page 425, Auriferous Gravels) to yield 6⅗ cents per cubic yard. This rate will yield a profit.

When the hydraulic process is not applicable, mining may in special cases be continued by drifting. This method is followed in some of these mines. The amount of detritus thus produced is a small percentage of that due to the hydraulic process.

Other rivers.—Mr. Manson refers in his report to the prospect of new properties being opened on the Upper Feather, in positions where it will be difficult, if not impossible, to provide restraint for detritus.

As for the existing mines on the Feather, it appears that the groups on the upper waters already find natural storage for their detritus in great part, and, so long as this condition is fulfilled, the magnitude greater or less of the operations need not be considered.

On the Lower Feather, near Oroville, there are considerable bodies of gravel, the amount of which is not known. It will be seen by Mr. Manson's report that he was unable to find storage for the product of these mines.

Lieutenant Payson furnishes the following information in regard to the Cosumnes and rivers south of it.

At "Hill Top," on the Cosumnes, the superintendent told me that an estimate had been made, based on their previous rate of working; that they had gravel enough remaining to last from ten to eleven years.

I was able to make here a very close estimate of the duty of an inch, stated in my report of last year as 2.4 yards. This, with the water supply of the mine, would indicate for the remaining gravel between 11,000,000 and 12,000,000 yards.

From its source this is probably a liberal estimate for the mine, and since it is the only one of any consequence on the river, will probably cover the remaining supply for it; also Jenny Lind mine on the Calaveras.

The water supply now is 550 inches for six months in the year. They expect to get soon 1,000 inches throughout the year.

The superintendent estimates the gravel remaining as sufficient for twenty-five years at their present rate of progress, or fifteen years with their expected increase in facilities. From the circumstances of the case I think this estimate was made with care. As they probably move from 800,000 to 1,000,000 yards per annum now, this would correspond to a remaining supply of say 22,500,000 yards.

This will probably all be worked, and can be safely said to include the total remaining supply for the lower river which lies in such a position that it can be worked.

There remain enormous additional amounts in the deposits about Mokelumne Hill, but as described elsewhere they are not favorably situated for working, and the cessation of hydraulic operations for this reason will precede by a long time the exhaustion of the gravel supply.

No approximation can be given by me to the quantity now available.

The remaining deposit of consequence is found in the newly opened mine at Dogtown (Juniper County). This has not been developed, but promises to be extensive, and has good facilities for working.

The only other large mine now in operation on the southern rivers is that at La Grange. This has probably, since it began, moved over 16,000,000 yards. The space left by this removal seems but a small fraction in the area of the remaining deposits.

The superintendent told me they considered their supply of gravel as "inexhaustible," but the facilities for working it very bad.

The Golden Rock Deposit on the upper Tuolumne I did not see. Its owner told me that the deposit was 10 miles in length and the beds 100 feet deep in places.

The aggregate amount of gravel not subject to the hydraulic process, but workable by drift mining must be considerable, and the development of this kind of industry promises to take greater proportions as wages of miners become less. It is probable that this description of mining will continue for several generations.

REMEDIAL MEASURES.

The statement of the case presented in the preceding pages seems to establish the necessity for measures of remedy or alleviation, even in the event that no further contribution be made to mining detritus in the beds of streams.

We may now inquire whether any remedy is practicable and general for all mines and all circumstances, or whether there are mines producing detritus or existing deposits of detritus, so situated as to be beyond the application of a remedy.

Mention has been made of basins lying near the Feather and American rivers, the surfaces of which are below the level of average stages of the rivers. It is in some cases possible to direct streams from their present courses and turn them into the low-lying lands, with the effect to make a place of deposit for mining material.

Diversion of the rivers in all their stages is essential to this project. Partial diversion or separation of a stream into parts, by lessening the transporting power, would aggravate present evils. The present objections on account of expense and other considerations are sufficient to make us defer further reference to the project. If, however, in the future it shall become desirable to undertake a fuller consideration of the scheme, account must be taken of the fact already established that the mining streams are not generally able to carry to these basins in a year anything like the full amount of detritus which they receive. It is in consequence of this fact that their beds when inclosed by high banks are rising year by year, and when not so inclosed are undergoing obliteration.

The preservation of river beds and routes of drainage requires that effective restraint be imposed upon mining detritus. Otherwise these drainage lines may be expected to suffer the fate which overtook their prototypes, the Pliocene rivers, which were obliterated by enormous deposits brought down by their own currents.

It may be added that the conservation of existing facilities for navigation equally requires restraint of the flow of sand and gravel and that no important improvement of the channels can be expected until this result shall be secured.

Under all circumstances, restraint is the first and essential step to any projects whether of alleviation, conservation, or improvement.

It has been shown that in the beds of the American, Bear, and Yuba there are now lying many millions of cubic yards of material, in positions where it is comparatively harmless, and that each year as a rule adds something to the volume of these deposits, but that whether anything is added or anything subtracted, which is sometimes the case, depends upon the volume and power of the floods.

As a rule the mines supply more material annually than the floods are able to transport over the grades in the lower portions of the rivers. If the floods were of sufficient duration, the accumulations would be formed lower down, and in more dangerous positions. Instead of lying in the bed of the Yuba, they would be in the Feather.

Taking the Yuba as an instance, the great deposits of finer grades of material are near and below the foot-hills on slopes of 10 feet or less to the mile. The heavier classes of material are found in greater abundance higher up the streams on grades of 20 or 30 feet to the mile.

Now if we place across the river beds barriers some feet in height, the slope of the bed above will be reduced, and with it the transporting power of the water. The deposits now taking place will be aided and increased. When the material is gravel and sand, the river bed will be filled to the crest of the dam and be graded back on a slope determined by the nature of the material, the width of the channel, and the volume of the floods. This proposition is not only in harmony with principles of hydraulics but it is abundantly proven by results of experience on the Bear and American rivers.

When the banks are sloping, as is the case generally in the cañons of the mountain streams, the elevation of the bed increases the width. These slopes are more generally 35°, and an elevation of the bed of 50 feet adds 140 feet to the width. This extended width reduces the heights of floods, the cubes of the heights being proportional to the squares of the widths.

Doubling the width reduces the height one-third. The reduction in the heights of floods is an important gain in two respects. It reduces the suspending power of the water, and in this way and to some extent favors the deposition of material. It also reduces the exposure of the structure in floods.

Another important feature is the increase of the storage volume, consequent upon this increase of width.

A permanent structure will make permanent storage, for the reason that it will prevent the river at any time from eroding the deposits to the original bed, which otherwise would take place sooner or later.

It may be asked whether the protection afforded in this way will be complete, and include all grades of mining tailings. This cannot be claimed. The suspensory matter of fine sands and clay cannot be restrained in this way or by any other method which does not provide a settling basin in which the water can be maintained in a quiescent state for some time.

It may also be expected that during the flood stages in the early period of development, a certain portion of material of every grade may be suspended, and thus pass the crest of the barrier, but it is to be remarked that as the width is increased the suspensory power is diminished, so that the degree of protection becomes greater as the system is developed. We can imagine a condition of a river when comparatively little is carried suspended, and nearly the whole of the material transported is rolled in waves on the bottom.

This condition is more and more approached as the dams are raised. It seems therefore to be good policy to give the first dam in the cañons considerable height.

It will be understood that permanent protection can be attained only by building dams in proportion to the amount of detritus turned out by the mines. The system must be continued at least as long as the mines are worked.

If this system of restraint had proceeded *pari passu* with mining during the past thirty years it can hardly be doubted that the condition of the country affected would to-day have been much better than it is.

A system begun now is obliged to deal not only with the current action of the mines, but is also compelled to contend with the accumulated difficulties of thirty years.

The same principles apply to the large deposits of finer materials that are found in the plains, particularly on the Yuba and Bear.

A considerable mass of detritus has, however, reached positions in which no control can now be exercised, but so far as barriers can be applied to hold the sands in their present position it is thought that they ought to be constructed.

In particular mines it is possible to store all the detritus before it reaches the river-beds, and perhaps in many cases partial storage is possible. It is needless to remark that this kind of storage ought to be insisted on whenever it is practicable.

The amount of storage that will be secured by a barrier of given height is in our present state of knowledge to some extent indeterminate. It depends in any case directly upon the grade of equilibrium which the material takes behind the barrier, and this cannot be regarded as constant, for it must depend upon the violence of floods, in which respect there is much variation.

It cannot be doubted that as the bed is widened and the height of floods thereby reduced, material of a given size will be found to be in equilibrio on a grade steeper than that of equilibrium in the original bed. This secondary effect of width shows that the storage prism will grow in a greater than arithmetical ratio as the dams are raised and the widths increased.

The barriers or dams, to be permanent, must be made of stone in all exposed parts. If wood is used it must be in circumstances where it will be kept wet.

In the cañons the dams will consist of a mass of stone blasted from the side hills and deposited with only sufficient care of arrangement that no continuous currents can be established through the structure, and that the velocity of the water shall be broken by repeated falls. For purposes of estimate, the dams are projected with slopes of 1 upon 1, and 1 upon 4, above and below, respectively, but an arrangement of stones on the lower face to an uniform slope would be a serious error in construction. The more this slope can be broken by falls and the rougher its outline, the more effectually will the destructive action of the water in severe floods be counteracted. In order to fulfill these necessary conditions, it is essential that the quarry shall supply large stones, the larger the better, for exposed positions, and smaller grades to measurably fill the interstices of the larger.

Where the foundation is natural rock, it is proposed to use only stone, but in cases where the foundation is gravel or sand, a grillage or mattress of timber or brush will be required to prevent settlement.

The purpose of barriers or dams being to restrain sand and gravel, and not to impound water, it is not essential that they shall be impervious, nor can they be water-tight. Being unable to store water, it is impossible to conceive them, in the event of breach, as capable of inflicting disaster upon riparian inhabitants below. Nor could a breach cause an unusual flow, to any greater distance, of detritus in a given flood, for the reason already established, that floods are now fully loaded with all the material they are able to carry. The result of a breach, however serious, could therefore be only to restore conditions now existing. Moreover, it is impossible to conceive sudden and wholesale disaster overtaking one of these structures. They may settle, and their usefulness may be impaired, but being simply a mass of large rubble stone without bond, disaster cannot take great proportions or be an element of sudden danger to persons or property.

In cases where brush or timber is much cheaper than stone, it will be permissible to use it more freely and make a considerable part of the structure of this material—afterward covering it with stone. The moisture below the surface of the river-bed may be relied upon to keep the wood wet, and the covering will protect it from the rays of the sun.

It may be well to say that while structures for the same purpose have been used in the Alps and Apennines, there has been no occasion elsewhere to require dams of the same dimensions. They are to this degree novel, and their exposure in floods may require attention and expense in repair.

The sites for the dams ought to be such as will give the maximum storage above, and, to this end, the larger the area and the lighter the grade of the river the better will be the position.

This system of restraint has been put in operation in a partial and insufficient way by the State of California, in the construction of two brush dams, one in Bear and the other in the Yuba, at the edge of the foot-hills. They were described in the report of January 10, 1881. On this date they were standing intact and doing good service. Later they both met with misfortune, and considerable portions of each were carried away. A report of their condition in the summer of 1881 will be found in Appendix 3. They have not been repaired, the State having relinquished any attempt to deal with the engineering features of the case, owing to the unconstitutionality of the act of the legislature under which it was acting.

By a comparison of survey in 1880 and 1881, it was found by the office of the State engineer that 4,851,000 cubic yards were impounded above the Yuba dam. Above the Bear River dam 961,000 cubic yards were impounded.

These dams serve the purpose of controlling deposits on the plains to a certain and beneficial degree, and it is thought that good policy requires them to be repaired and raised. Perhaps, subsequently, they ought to be covered with stone.

In the application of this system it will be plain, from what precedes, that the Yuba presents the case, of greatest necessity, and requires the greatest storage volume. The American and Bear also require the system.

As to the Feather, it appears from the report of Mr. Manson, hereto appended, that the cañons of the Feather are unsuitable for storage, and, what is quite satisfactory under the circumstances, that the extent of mining on its upper waters, and the amount of injury resulting therefrom, are not of such a character as to require remedial measures.

It is not so, however, with the mines on the lower Feather, in the neighborhood of Oroville. These mines discharge into the Feather at points below which there is no opportunity to store the detritus.*

A group of mines 12 miles north of Oroville, at Cherokee, the principal of which is the Spring Valley mine, at present need no attention, for the reason that they do not contribute to the navigable waters any material capable of being stored. The heavier material is stored below the mines, at the edge of the foot-hills, and the remainder is deposited on lands lying between the mines and the Sacramento River. It is thought that no considerable quantity reaches the Sacramento River.

In regard to the Cosumnes, and the rivers to the south, the damage done thus far is comparatively insignificant, and the prospects of mining are not very favorable.

Reservoir sites have been examined which will serve when the occasion arises for their use. The Calaveras, it is now thought, may be the first of the southern streams to require the application of the system, and an excellent site exists for the purpose. For special information in regard to these rivers, reference may be made to the report of Lieutenant Payson, hereto appended.

The following statments embrace the measures and constructions which are recommended for the Yuba, Bear, and American rivers, with estimates of cost of the system maintained for a series of years.

Yuba River.—It is recommended to occupy at once two sites for storage, and after several years a third.

The first and upper site is at the narrows just above the mouth of Deer Creek, which enters the Yuba about 12 miles above the plains.

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* This group of mines is in a position to do special injury to Feather River, as may be seen from Mr. Manson's report, Appendix 2, to which reference is made.

The next two sites are below on the edge of the plains, one at De Guerre Point, and the other the brush barrier built by the State of California.

The features of the upper site are these:

The width of the river-bed is 270 feet; the banks slope at angles with the horizon between 32 and 50 degrees for a height of 200 feet. There is an abundance of stone in convenient positions, and favorable as to quality and sizes. Mr. Manson observes that it will quarry in pieces varying from 2 to 30 tons.

The river for 44,500 feet above has average width of 300 feet, with a fall of 22 feet per mile. The banks have inclinations of 30 to 35 degrees. The South Yuba joins the river 8 miles above the site. In the future development of the system this stream will afford considerable additional storage.

The height of floods is 12 feet.

The storage is calculated on a grade behind the dam of 14 feet per mile. The grade of the top surface of the prism is held constant in the calculation. We know that the grade for given material must become steeper as the river-bed is widened. The probable storage is therefore in excess of the tabulated amount. No allowance is made for material necessarily escaping, or for that that may remain stored above the reservoir. Both of these points are assumed at the worst. The estimates are therefore larger than they would have been if allowance had been made for these considerations.

The Deer Creek site is below all mining dumps except those of the Smartsville Group and the minor output at Sicard Flat and Dry Creek.

The length of river-bed taken by the reservoir, formed by a dam 75 feet high on a grade of 14 feet, will be 9 miles, obtained by dividing the height of the dam by the difference between the present grades and that assumed for the future grade.

The lower site may be either De Guerre Point, or that of the Brush Barrier, erected by the State in the year 1880. This structure was much injured by natural causes in 1881. A detailed report of these injuries will be found in Appendix 3. Since the date of that report the dam has been injured by fire, applied, it is supposed, by design. Its present condition is worse than it was when examined, but to what extent is not known.

The advantage of restoring this structure is that by its position it exercises restraint of considerable amounts of sand and gravel already in the plains, which otherwise will be free to move below to navigable waters, and serve to threaten the town of Marysville still more.

The project consists in repairing the breaks in the dam and restoring it to the original height in the first year, at a cost of $80,000. In the second year to cover it with stone to the depth of 4 feet, raising the height of the dam 4 feet.

The estimate contemplates, first, the construction of a dam at the Narrows, then the restoration of the Brush Dam and covering it with stone, the De Guerre Dam being the last undertaken.

The yearly expenditures for a series of years are given in the accompanying table, as nearly as they can be foreseen.

Table showing estimates and order of structures upon Yuba River for ten years.

Year.	Structure erected or raised.	Annual cost.	Total cost.	Storage provided by each structure.	Total storage provided.
				Cubic yards.	*Cubic yards.*
1	Build the [illegible]ws Dam to a height of 75 feet	$224, 779			
	Repair the Br[illegible] Dam	80, 000	$325, 000	30, 000, 000	30, 000, 000
2	Cover Brush D[illegible] with stone	137, 000	462, 000	10, 000, 000	40, 000, 000
3	Raise the Narrows Dam 25 feet	113, 807	576, 000	25, 000, 000	65, 000, 000
4	Erect De Guerre Dam 5 feet	100, 000	676, 000	10, 000, 000	75, 000, 000
5	Raise De Guerre Dam 5 feet	110, 000	786, 000	15, 000, 000	90, 000, 000
6	Raise Narrows Dam 25 feet	90, 734	876, 000	31, 000, 000	121, 000, 000
7	No expenditures.				
8	Raise De Guerre Dam 5 feet	74, 000	950, 000	20, 000, 000	141, 000, 000
9	Raise Narrows Dam 25 feet	122, 000	1, 072, 000	36, 000, 000	177, 000, 000
10	Raise De Guerre Dam 5 feet	63, 000	1, 135, 000	17, 000, 000	194, 000, 000
	Total	1, 135, 000		194, 000, 000	

Average yearly cost for ten years, $113,500.
Average yearly storage provided, 19,400,000 cubic yards.

The site selected for a dam in the Bear River Cañon is at or near Van Giesen's Dam.

The width of the river-bed averages 53 feet at the site; the side slopes are 15 degrees and 20 degrees. The rock is trap, and the foundation will be on rock. The reservoir space above consists of the river-bed, which in some places is flanked by low banks, which increase the area for storage. The bed for 11 miles above the site is covered to considerable depth with sand and gravel, on a slope of 25 feet to the mile, the average width being 350 feet.

The storage prism is calculated on a grade of 19 feet per mile, being the observed line of deposit due to a dam once occupying the site, and carried out in the past few years.

The first structure is estimated at 30 feet in height. The successive additions, with cost and storage capacities thereby acquired, and that due to the repair of the brush structure erected by the State at the débouch of the rivers on the plains, are shown in the following table.

A further examination of the levels on the plains needs to be made to settle definitely whether storage after two or three years cannot be secured more thoroughly by occupying lands which lie further down the river, and which have been injured in a greater or less degree by deposits of sand and slickens.

Table showing the order recommended for structures on Bear River.

Year.	Structure erected or raised.	Annual cost.	Total cost.	Storage provided by each structure.	Total storage.
				Cubic yards.	*Cubic yards.*
1	Erect the Van Giesen's Dam 30 feet	$34, 600		6, 700, 000	
	Repairs, Brush Dam	45, 500	$80, 100	5, 300, 000	12, 000, 000
2	Cover Brush Dam with stone	75, 000	155, 100	5, 000, 000	17, 000, 000
3	No expenditures.				
4	Raise Van Giesen's Dam 10 feet	12, 500	167, 600	5, 800, 000	22, 800, 000
5	Raise Van Giesen's Dam 10 feet	16, 400	184, 000	9, 200, 000	32, 000, 000
6	No expenditures.				
7	Raise Van Giesen's Dam 10 feet	20, 500	204 500	10, 200, 000	42, 200, 000
8	No expenditures.				
	Total	204, 500			

Average yearly cost for eight years, $25,600.
Average yearly storage provided, 5,200,000 cubic yards.

It is recommended to occupy two dam sites on the American, one on the North and one on the Middle Fork.

The site on the North Fork is about 1¼ miles above the junction of the North and Middle Forks. The width of the river-bed at the site is 75 feet. The banks are hard trap, with slopes of 32 and 42 degrees. The river-bed above the site for about 20 miles has a mean width of 250 feet, and a slope of about 23 feet to the mile, with side slopes of 25 to 30 degrees. The contents of the prism are calculated on a slope of 18 feet to the mile.

On the Middle Fork, the site selected is about 12 miles above the junction of North and Middle Forks, and about 2 miles above the mouth of Cañon Creek.

The width of the river-bed is 90 feet, and the side slopes 42 and 55 degrees.

The river-bed above is 125 to 150 feet in width, and the slope 45 feet to the mile. The slopes of the bank vary from 30 to 35 degrees.

Table showing the order recommended for structures upon the North and Middle Forks of American River.

Year.	Structure erected or raised.	Annual cost.	Total cost.	Storage provided by each structure.	Total storage provided.
				Cubic yards.	*Cubic yards.*
1	Erection of North Fork Dam	$24,600		5,500,000	
	Erection of Middle Fork Dam Cañon Creek	81,900	$106,500	3,400,000	8,900,000
2	Raise Middle Fork Dam 50 feet	38,100	144,600	10,000,000	18,900,000
3	Raise North Fork Dam 10 feet	8,600	153,200	5,400,000	24,300,000
4	No expenditures.				
5	Raise North Fork Dam 10 feet	10,800	164,000	7,600,000	31,900,000
6	No expenditures.				
7	Raise North Fork Dam 10 feet.	13,200	177,200	10,200,000	42,100,000
8	No expenditures.				
	Total	177,200			

Average yearly cost for eight years, $22,150.
Average yearly storage provided, 5,200,000 cubic yards.

For detailed information in regard to the circumstances of each reservoir and upon many other points of this report, reference may be made to the intelligent reports of Lieutenant Payson and of Mr. Marsden Manson, assistant engineer, which are attached as appendixes.

The estimate for the first year's operations on the Yuba, Bear, and American rivers is $511,600.

Respectfully submitted.

G. H. MENDELL,
Lieutenant-Colonel, Corps of Engineers.

The CHIEF OF ENGINEERS, *U. S. A.*

REPORT OF LIEUT. A. H. PAYSON, CORPS OF ENGINEERS.

SAN FRANCISCO, *December* 30, 1880.

COLONEL: In obedience to the instructions in your letter of the 27th instant, I have the honor to submit the following preliminary report of the result of examinations made last summer, under your direction, in compliance with the act "to preserve the navigable waters of the State from injury by mining *débris*."

The drawings of the surveys not yet having been finished, much data, which they were expected to furnish, is unavailable, and this report is therefore necessarily incomplete in details, and in some points only the record of impressions which cannot be definitely confirmed by facts.

On reporting to you for this duty last August, it was decided, after consultation with the State engineer, that since his examinations in the last two years had, or would have, pretty thoroughly covered the drainage basin of the Sacramento, our surveys should be confined to the valleys of the southern rivers, tributary to the San Joaquin, about which there was but little existing information. These are, in their order from north to south, the Mokelumne (with its affluents the Cosumnes and Dry Creek), the Calaveras, Stanislaus, Tuolumne, and Merced.

Taking the field with my party on August 23, surveys, more or less in detail, were made on all of these, except the Merced, a personal inspection of which had convinced me that it called for nothing more in connection with the subject of this report.

These surveys were in general merely a line up the valleys with cross-sections of them at short intervals extending from the cañon proper down through the last undulations of the foot-hills to the plain. They were made more carefully at such places as were deemed suitable for the future storage of detritus, and such contours fixed as would form the basis for a tolerably accurate estimate of their capacity.

All information available was collected touching mining, the use of water, and the changes which the beds of the streams and lands adjacent had undergone, in the recollections of persons familiar with them.

The results of these surveys will be presented in maps of sites on each river where storage reservoirs were thought practicable, with estimates of capacity and cost. A series of plane-table sketches of the Mokelumne, Stanislaus, and Tuolumne in their course through the lower foot-hills, and sheets of cross-sections and profiles on all the streams examined.

The organization of the field party was as follows: one transit man, one plane-table man, two levelers, six rodmen, two teamsters, one cook.

I append summary of the instrumental work.

Number of working days, 64; total distance run, 1,084,439 feet = 205.4 miles; average per day, 16,944 feet = 3.21 miles. The plane-table topography followed the transit line 601,223 feet, or 113.98 miles.

The field party was disbanded at Stockton, on November 23, since which a force has been engaged upon the necessary office work.

GENERAL TOPOGRAPHY.

While each of the southern rivers falling from the east into the San Joaquin has its own distinctive features, they are all alike in certain general characteristics. On each there is one point where the cañon proper abruptly ends and the valley begins. Above this the sides are precipitous and formed of rock in place, and though for a short distance they may widen out here and there to inclose those deposits of coarse gravel, termed "bars" and "flats" by the early miners, there is no properly so-called alluvial or bottom land. Below, while the undulations of the foot-hills continue, the upland banks, though sometimes approaching each other in points, are generally separated by a wide stretch of fertile bottom, until finally this distinction disappears and both become merged in the general level of the plain. The slopes will meantime vary from 2 or 3 feet per mile in the plain to 8 and 10 feet at the entrance to the cañon, thence increasing rapidly in the first few miles to 20 or 30, or even 40 feet.

As we go south and the average height of the main San Joaquin Valley increases we find that its tributaries have worn for themselves deeper notches in the country, the modern alluvial banks are higher and narrower, while above them will be a second, and sometimes even a third, terrace of older origin and coarser material.

Crossing the plain parallel to the San Joaquin and 10 or 15 miles east of it, the courses of the Cosumnes, Mokelume, Dry Creek, and Calaveras are marked by a line of growth in the otherwise treeless distance, while on approaching the Stanislaus, Tuolumne, or Merced nothing is seen of the river until just at its edge, whence its valley is looked down into from bluffs 80 to 150 feet in height, and on the two last-named this peculiarity is preserved nearly throughout their length. While this distinction affects directly the capacity of these valleys for the future storage of detritus, there is another, perhaps, even more important, in connection with this examination.

The three southern streams fall directly into the San Joaquin in its upper course, to the detriment of the most critical part of its navigation, while the others have their outlet through a network of tidal arms in low tule lands, and are thus given a place of harmless deposit for much of their sedimentary load when spread out in times of flood.

In this connection it is to be noted that while the original channel of the Calaveras had its exit in a tidal arm north of Stockton, its water is now taken at low stages, from a point 12 miles below Jenny Lind, through Mormon Slough, around by the south and west of that city.

Since the discharge in the dry season is entirely the result of mining, it is highly charged with sediment, and it would seem advantageous to restore, if possible, the former state of things and thereby avoid the probable deterioration of the lower part of Mormon Slough, which is valuable for commercial purposes.

A special survey was made at the point of diversion, and developed the fact that the whole country on both sides being submerged in times of flood, there seemed no way of permanently preventing it at reasonable cost.

The low-water might be forced into the old Calaveras bed by a temporary dam; but the building of such a one would be strongly opposed by the property owners on Mormon Slough.

The plane-table sheets of the survey show the course of both water-ways, with levels, cross-sections, and flood lines.

Before the destructive effects of gravel mining had made themselves felt in these valleys, the streams, perfectly clear in low stages, were between high and solid banks grown with large timber, and though these were overflowed in exceptional seasons, the floods staid but a short time on the land, and were of benefit rather than harm. The soil was a black loam and very rich. The first and greatest of the change came during the extraordinary flood of 1861–'62. In that winter immense masses of detritus, the result of ten years and more of mining, were swept down along the rivers, their beds were choked and raised, their banks torn out to excessive widths, and large areas of good land ruined from being thickly overlaid by sand and gravel.

Since then the deterioration of the water-ways has been steadily going on, and the duration and height of floods increasing, till now it is difficult to find anywhere the original black soil uncovered by the lighter colored modern sediment, while even in the lower portions of the valleys coarse sand has been swept over them in streaks and patches of considerable extent and depth.

But all the rivers have not been equally affected. The Cosumnes is now by far the worst of the southern streams, though even on it the destruction does not approach in magnitude that on the Yuba and the Bear. Its bed at the mouth of the cañon has been substantially obliterated, the deposits being nearly level with the banks, and below for several miles has been torn out to five and six times its normal width, and choked with sand and gravel. From pretty reliable testimony I have estimated the filling of its bed at 6 feet 8 miles above the railway crossing, 15 feet at a point 17 miles above, and 20 feet at the entrance to the cañon, which would correspond to a deposit of some 6,000,000 yards, and a diminution in the water-way of 70 per cent.

Next to the Cosumnes in order of damage comes the Calaveras, and although here the ill-effects are not so marked just now, it is the most threatened of all, both from the probable future of hydraulic mining, and the present choked condition of its own and tributary cañons.

The most important, however, under the purposes of this act, is the Tuolumne. Besides being the largest of the rivers considered in this report, and formerly itself navigable for some 15 miles above the mouth, it empties into the San Joaquin below and near the head of its navigation, upon which it immediately produces a marked and prejudicial effect. Though badly filled, probably 15 feet, at its exit from the cañon, and much spread out, for 10 or 12 miles below its bed soon gets between high and well-defined banks which are now only overtopped by the higher floods.

The Stanislaus, though the deep places in its bed have been filled up to a uniform grade, and its channel-way considerably widened for some 10 miles, has not been appreciably raised in low-water level at Knight's Ferry, in the foot of the cañon; its water is quite clear in low stages, and its banks seldom overflowed in floods, and then only for very short periods.

The same description will apply to the Mokelumne; but its bed has probably been raised 5 or 6 feet at Lancha Plana, and its floods are more frequent, and spread over wider and more valuable tracts of bottom land. Sutter, Mule, Dry, and Jackson creeks uniting, and called thenceforth Dry Creek, are all badly filled up with tailings in the cañons, and for some 8 or 10 miles below them have caused considerable injury to the bordering farms. More detailed descriptions of these streams will be given hereafter, but the preceding will perhaps serve to give a general idea of their present condition and the changes they have undergone.

MINING COSUMNES.

On the Cosumnes the chief, and in fact only, dydraulic mine of consequence, is near the foot of its cañon, four miles below Michigan Bar, at "Hill Top." Here are extensive gravel deposits, in a high ridge, between the main river and Arkansas Creek. The banks vary from 15 to 60 feet in depth, and overlie a whitish volcanic ash, which softens on exposure and is readily cut by the water in the sluices. They have been worked many years, with small heads, 30 to 50 feet, and the dumps in various ravines, on both sides of the ridge, are now so choked with the large masses of tailings, which have been permanently lodged in them, that the grades obtainable are very light, 4 to 5¼ inches to the 12-foot box. The remaining supply is estimated as sufficient for ten or eleven years.

Beside the Hill Top claims there are nothing but some insignificant placer workings, and the operations of the Chinese along the bars.

On the upper part of Dry Creek and its tributaries are various gravel deposits, of which the most important, and hitherto most extensively worked, are at Irish Hill and Mount Ophir, in the foot of the cañons of Dry Creek and Jackson Creek, respectively. These mines are alike in character to those at Hill Top, and are now worked with small appliances, and in rather a spasmodic way, for seven or eight months in the year. The richest parts of them have been worked out, and they may be said to be well nigh exhausted. Besides these there are some unimportant gravel and placer workings; but, at

VOLCANO,

on Sutter Creek, is a mine of somewhat different character, which threatens considerable damage to the stream. A rocky ridge here dams the creek, and behind this lies a mass of gravel, said to be very rich, but which has hitherto been but little explored, from the difficulty of keeping water out of the excavations. A tunnel has been now nearly finished which starts from the side of the creek, about 1½ miles below the deposit and, working up under the bed, taps it about 40 feet below the surface. Through this tunnel, which is now 8 feet in the clear, the material is to be washed with an ample supply of water, the waste going directly into the stream.

On the Mokelumne, for 3 or 4 miles below Lancha Plana, the banks are honey combed with former gravel claims, some of quite large size, but now mostly all abandoned for want of grade, in which they are necessarily all deficient. Some, however, where the material is rich enough to pay for excavation, are being worked in that way; notably the Storey claim, just below Lancha, from which a very large quantity of earth has been taken.

Back from the river a little, and near Comanche, Campo Seco, and Chili Camp, are remains of hydraulic mining operations on quite an extensive scale. They are now, to a great degree, given up, though some are yet going on for six or seven months in each year, with very small heads and supply of water and the usual difficulty in the way of grade.

Farther up the river, near the town of Mokelumne Hill, is quite a good-sized mine on what is known as Stockton Ridge; but it will be exhausted in a year or so.

One other small hydraulic claim on the headwaters of the South Fork, at Railroad Flat, with some quite extensive Chinese river mining, completes the account for the Mokelumne.

Crossing the Stockton Ridge through Mokelumne Hill, we come to the head of Chili Gulch, one of the northernmost of the various small streams into which the upper Calaveras is divided. Among this for several miles are a number of large hydraulic mines. They have good heads—150 to 250 feet—but are scantily supplied with water and generally deficient in grade. The most important is the "Happy Valley," said to be a fine property, but now all out of grade. To get it, a tunnel 2,000 feet long has to be built, which has already been driven about 300 feet, and will be pushed to completion.

Chili Gulch itself, from a mere ravine, has been spread out into a broad mass of tailings, on both sides of which the enormous quantities yet remaining in the dumps have been washed out into high and nearly vertical banks. Much of the gravel about here is lava-capped, and some of it is worked by drifting.

Four miles from Mokelumne Hill, on the bank of the north fork of the Calaveras, is another small hydraulic mine, called the Cook Brothers; and thence, crossing its watershed to the south, we find nothing but some unimportant workings near San Andreas till we reach its south fork, commonly called Santo Domingo Creek.

On the left bank of this, at Dogtown, near Altaville, is an extensive gravel deposit, said to be rich. It has thus far been little worked, but arrangments have been made for a large supply of water, with heads of more than 300 feet, which will be available in the present season.

But the largest and most important of all the Calaveras mines are now those at Jenny Lind, in the foot of the main cañon. The whole country hereabout, for miles south of the river, is a deep gravel bed; but only that ridge which is just bordering on it can get the necessary dump. The principal claims are at Whisky Hill, Bunker Hill, and North Hill, all owned by the same company. The two latter have been worked some twenty years, though only in the last five or six years with modern appliances, and are now about exhausted. The material is fine and easily moved, resting upon a very deep bed of cemented gravel, also auriferous, but impossible to work for want of grade. At North Hill the gravel is about 30 feet deep, of the same character as that underlying Whisky Hill, with a bed of volcanic ash. It can only be mined by the free use of powder, and much has also to be broken in a mill before it can be washed. The supply remaining is estimated as sufficient for from twenty to twenty-five years, and the dump is in a long ravine, called "Rich Gulch," in which probably the greater part of the waste material, from its coarse and heavy character, will be stored. The water supply is now good and shortly to be increased; it is delivered under heads of about 200 feet.

Along the Stanislaus, for 4 miles or so below Knight's Ferry, a good deal of gravel mining has been done by old-fashioned methods, though nothing remains of it but two small claims, each owned by a single individual and worked in a small way for seven or eight months a year. Higher up, in the neighborhood of Murphy's, Vallecito, and Douglas Flat on the north, and Columbia on the south, a good deal of water is used in various mining operations, which drains into the river. But these are all far back on various small tributary water courses, and consist largely in the washing of excavated material, so that their effect on the main stream may be regarded as insignificant. Coming now to the

TUOLUMNE,

we find at La Grange the largest and most important mine on any of the southern rivers.

The gravel is in beds from 30 to 300 feet in depth and practically inexhaustible in quantity; but the mine is very badly off for grade, the best and deepest claims being now abandoned for want of it.

Some of the workings tail into the Tuolumne and depend on the winter freshets to clean away and renew their dump, others into ravines which are becoming so choked that only the higher portions of the deposits are available.

The supply of water is ample at heads of 60 to 120 feet; but the grades of the sluices have been reduced to 3½ and 4 inches to the 16-foot box. The bed rock is green-stone and serpentine, overlaid in many places by a stratum of the common volcanic ash.

Higher up on the Tuolumne, some 12 miles beyond Garrote, is a body of gravel, which, for some distance, lies right on the top of the divide between that river and the Merced, and then separates into several smaller and parallel ridges between the main crest and the latter stream. The beds are more than 100 feet deep in places and some 10 miles in length. They have for some time been worked under great disadvantages, as regards both head and dump, with the drainage to the Merced.

Prospect shafts are now being sunk to develop the channel and decide whether it will pay to build the tunnel necessary for "bottoming" the claim, which, if finished, will take the waste to the Tuolumne. The supply of water is large, but, there being scarcely any other demand for it, its future use depends almost entirely on the mine.

North of the Tuolumne, about Columbia, there is a good deal of placer and drift mining, and, near Jamestown, are some small hydraulic claims. The drainage from these is mainly by Wood's Creek, and their effect on the river probably very slight.

In the preceding brief description it is believed that every mine or mining district of any importance has been referred to. It has failed in its object if it has not given the impression that hydraulic mining along the southern rivers appears to be upon the wane. That it is so seems the general opinion among mining men and others, though there are yet many to be found who still hope for new developments, or the future diversion of capital when the more northern deposits show signs of exhaustion.

USE OF WATER FOR MINING.

During the season I made a special effort to get as precise information as possible about the use of water for mining purposes. I think I saw the owner or agent of every ditch of consequence, and in all cases found them ready to tell what they knew of the matter and give the freest access to all data in their possession. But in all mining localities new claims or mills are constantly starting and old ones being abandoned, or reworked; while the measures in general use of the quantities served out are variable and imperfect. A miner's inch possesses a very different value for miner's purposes, as it is delivered to him at varying heads, and the ditch companies, recognizing this fact, make special arrangements in many cases; so that while nominally selling by the inch they are really doing so by the mill or claim. With the best intentions, therefore, it is often impracticable for them to give the exact facts, and, in spite of the facilties furnished me, I find it difficult in many cases to reconcile apparently conflicting information, and necessary in order to do so to make assumptions, which are very possibly incorrect.

The safest guide I have believed to be the actual capacities of the ditch, for under whatever arrangements the water may be obtained, it can be assumed that but little will be wasted where mining in its various forms is the entire support and hope of the community.

The figures in the following table are submitted, therefore, only as the best approximation I could make; but it is believed that they are not far wrong, and that their errors are in being rather over than under the truth. It will be seen that two estimates are given for the Mokelumne, Calaveras, and Stanislaus. These are made necessary by an enlargement, which has already been begun in the works of the Mokelumne and Campo Seco Ditch, and the probable transfer of the Union Ditch to new owners, by whom its water will be used mainly in large hydraulic mines on the Calaveras, to the deprivation of numerous small gravel placer and drift claims near Murphy's, Vallecito, and Douglas Flat.

TABLE I.—*Water supply, its sources and points of final discharge after use.* [*Dumps.*]

Basins.	Mines.	Ditches.	Points of discharge.	Water used annually, 24-hour inches.	Annual summary 24-hour inches.	Remarks.
Cosumnes	Hill Top	Amador and Sacramento Canal and Mining Co.	Ravine mine to Cosumnes River.	456, 000		
	Various placers	Jordan	Cosumnes River	48, 000	504, 00	
Ione and Jackson Valleys.	Irish Hill	Amador and Sacramento Canal and Mining Co.	Dry Creek	162, 000		
	Various placers and hydraulic mines.	Amador Canal Co.	Jackson Creek	127, 750		
	do	do	Sutter Creek	54, 750		
	On Sutter and Mule Creeks	Johnson's	Sutter and Mule Creeks.	76, 000		
	Volcano-gravel mine	Volcano	Sutter Creek	365, 000	785, 500	
	To be opened near Buena Vista	**Daugherty's**	**Jackson Creek**	**43400**	**828,900**	**To be opened near B. Vista**
Mokelumne	Camanche, Campo Seco, Stockton Ridge.	Mokelumne	Mokelumne River	61, 000		
	Camanche, and near Lancha Plana.	Murray and Daugherty	do	118, 500	224, 500	
	R. R. Flat-Head of S. Fork Mokel	Clark's	do	45, 000		
	An increase begun and to be completed soon, will add			**30,250**	**254,750**	**An addition to be finished soon.**
Calaveras	Jenny Lind	Salt Spring Valley	Calaveras, through Rich Gulch	100, 000		At present.
At present	Claims near Mokelumne Hill	Mokelumne and Campo Seco.	Chile Gulch and Jesu Maria Fork of Calaveras.	133, 100		
	Juniper, at Dogtown	Union	St. Domingo Cr'k, through ravine	365, 000		
	Near Mokelumne Hill	Cook Brothers	North Fork of Calaveras	45, 000	643, 100	
	Jenny Lind	**Salt Spring Valley and Union.**	**Calaveras, through Rich Gulch**	**365,000**		After Union Ditch shall have been transferred, and Mokelumne and Campo Seco enlarged.
In future	**Claims near Mokelumne Hill**	**Mokelumne and Campo Seco.**	**Chile Gulch and San Domingo Creek.**	**200,750**		
	Juniper, Dogtown	Union.	San Domingo Creek	365, 000		
	Near Mokelumne Hill	Cook Brothers	North Fork of Calaveras	45, 000	975, 750	
Stanislaus	Placers and drift mines at Dougherty's Flat, Vallecito, and Murphy's.	Union Ditch	Coyote and Angel's Creek	500, 000		
	Placer and drift, Columbia and Shaw's Flat.	Tuolumne	To Stanislaus, through ravines	230, 000		
	Small hydraulic, below [illegible]ght's Ferry.	Burt's Ferry Ditch	Stanislaus River	38, 720	768, 720	
				Less, 500,000	**268,720**	**After transfer of Union D.**
Tuolumne	Placers and small hydraulic mines from Shaw's to Jamestown.	Tuolumne Water Co	Wood's Creek	380, 000		Totals. 4, 118, 320 24-hour inches at present.
	Hydraulic mine at La Grange	La Grange	Tuolumne River	812, 500	1, 192, 500	
	On Upper Tuolumne, to begin operating soon.	**Golden Rock**	**Tuolumne River**	**730,000**	**1,922,500**	**4,754,620 24-hour inches in future.**

REMARKS ON TABLE I.

The table gives less than 5,000,000 inches for the quantity of water used yearly for every kind of gravel, placer, or river mining in the district under consideration, while in this total there are nearly 1,000,000 inches included for the Upper Tuolumne, the future use of which depends on the development of a gravel deposit by the building of a long and costly tunnel.

From the State engineer's report, 6,379,000 inches are used annually on the Yuba alone, and 15,122,000 on all the tributaries of the Sacramento.

The quantities in the summary for the Stanislaus and Tuolumne give an exaggerated idea, because on the former stream 730,000 inches, or nearly all the supply, are used in washing material from excavations and in places where the waste will probably never reach the main rivers; while for the latter, 380,000 inches should be deducted for the same reason.

In the computations which follow of the material moved, these items in the water supply have been left out.

MATERIAL MOVED.

Estimates of the amount of material moved by water in hydraulic mining, based upon an average duty of the miner's inch, are very uncertain, disregarding even the considerable variation in that measure itself.

The work varies so greatly with the different character of the materials, grades of tail-sluices, heads, and the use made of explosives, that determinations are only good for the circumstances under which they are actually made. Character of material and grade are the ruling elements, the others being varied to supplement each other. That is to say, if the available head does not bring the bank down as fast as the tail sluices can carry the gravel away, it is helped by the use of powder; while on the contrary, where the deposits are deep and fine, high heads are at times a disadvantage, and the jet has to be managed with great caution to avoid choking the sluices up.

The work done by the jet on the bank will vary directly as the head, while the transporting power of a tail sluice increases with the third power of its grade.

I have two determinations of the earth moved by a miner's inch, one from an estimate of the mining superintendent at Jenny Lind, the other from my own at Hill Top, on the Cosumnes.

In the first case the material was a very coarse cemented gravel, which the head of 160 feet is unable to throw down without the free aid of explosives; the grade of the tail sluices $\frac{1}{16}$ and the quantity moved 2.1 yards per inch.

In the second the gravel is much lighter and easier to move; the head 30 feet, the grade from $\frac{1}{39}$ to $\frac{1}{36}$ and the quantity moved 2.4 yards per inch.

At Cherokee Flat, with generally very fine material in high banks, heads of 300 to 350 feet and grade $\frac{1}{32}$, the superintendent gives 5.5 yards as the work of an inch.

Throughout the southern country the lack of grade has caused and is causing the abandonment of many profitable claims, and, in fact, I know of but one case where the existing arrangements are satisfactory in this respect, namely, the North Hill mine at Jenny Lind.

Under these circumstances I have thought it fair to allow for the larger hydraulic mines 2½ yards per inch; for Jenny Lind and many of the smaller claims with low banks and deficient head, grade, and water supply, 2 yards; while in numerous instances of placer, river, and drift mining, where excavated material is thrown into sluice boxes, I have varied the amounts according to my knowledge of the circumstances.

The results are believed sufficiently large, but are so shown in the following table that they can easily be altered for any particular case. The quantity for the Calaveras is based on the probable future water supply.

TABLE II.—*Estimate of material moved annually.*

River.	Mine.	Ditch.	Water used, 24-hour inches.	Cubic yards moved per 24-hour inch.	Total number cubic yards moved.	Summary, cubic yards.	Remarks.
Cosumnes	Hill Top	American and Sacramento	456, 000	2½	1, 140, 000		
	Various placers	Jordan	48, 000		40, 000	1, 118, 000	Part of water used for power.
Dry Creek	Irish Hill	American and Sacramento	162, 000	2½	405, 000	405, 000	
Mule Creek	Various small placers	Johnson's	38, 000	1	38, 000	38, 000	
Sutter Creek	Various placers and hydraulic	Amador Canal	54, 750	1	54, 750		
	Volcano hydraulic	Volcano	365, 000	2½	912, 500		
	Various placers	Johnson's	38, 000	1	38, 000	1, 005, 250	
Jackson Creek	Various placers and hydraulic, M	Amador Canal Company	127, 750	1	127, 750		
	Near Buena Vista, at head of Jackson Creek	Dougherty	43, 400	1	43, 400	171, 150	
Mokelumne	Near Campo Seco, Camanche and Stockton Ridge.	Mokelumne	61, 000	2	122, 000		
	Railroad Flat, head South Fork	Clark's	45, 000	2	90, 000		
	Near Lancha Plana and Camanche	Murray & Dougherty	118, 500		60, 000	272, 000	Part of water used for power.
Calaveras	Near Jenny Lind	Salt Spring Valley Reservation and Union.	365, 000	2	730, 000		
	Chile Gulch and Jesu Maria Fork of Calaveras	Mokelumne	200, 750	2½	501, 875		
	Juniper, at [illegible]ogtown, San Domingo Creek	Union	365, 000	2½	912, 500		
	Near Mokelumne Hill	Cook Brothers	45, 000	2	90, 000	2, 234, 375	
Stanislaus	Near Knight's Ferry	(small)	38, 720	2	77, 440	77, 440	
Tuolumne	La Grange and Patricksville	La Grange	812, 500	2½	2, 031, 250	2, 031, 250	7, 352, 465 cubic yards. Total at present.
	On Upper Tuolumne, to begin operating soon.	**Golden Rock.**	**730,000**	**2½**	**1,825,000**	**3,856,250**	**9,177,465 cubic yards. Total in future.**

REMARKS ON TABLE II.

The total amount from all sources and for all the southern rivers is about 7,500,000 yards annually, against the showing in the State engineer's report of 22,326,500 yards for the Yuba alone, and 53,404,000 yards for the whole basin of the Sacramento.

In this connection the following is a statement of the number of stamps upon the same rivers, divided as they were in action or suspended when I heard of them:

Name of river.	Number of stamps.		Totals.
	Suspended.	Running.	
Cosumnes		80	80
Mokelumne		60	60
Dry Creek	20	130	150
Sutter Creek	5	120	125
Jackson Creek	35	120	155
Calaveras		30	30
Stanislaus		130	130
Tuolumne	74	174	244
Totals	184	842	1,020

These totals are believed correct for all the streams save the Cosumnes, about which I am uncertain.

The amount of waste in quartz milling should be estimated at from 2 to 3 yards to the stamp for twenty-four hours, and, though many of the mills are far from the main rivers, most of the product, from its extreme fineness, probably reaches them in time.

Eight hundred and forty-two stamps, at 2½ yards per stamp, calling a cubic foot of sand 100 pounds, give 1,555 yards a day, or 567,575 yards a year.

COMPARISON OF CALAVERAS AND TUOLUMNE.

I have before stated that the Cosumnes was the most damaged river, the Tuolumne the most important to protect, and the Calaveras the most threatened in the future.

In view of the fact that the yearly supply of detritus on the Tuolumne is over 2,000,000 yards now, with a possible increase of almost 2,000,000 yards in the near future, the latter statement requires some additional explanation. This increase is to result from the building of a tunnel, in case gravel deposits now being explored should justify it, and will enter the river some 35 miles above the mouth of its cañon, which is now quite clear of tailings, and barred near the foot by a high and massive dam. It can therefore, I think, be safely left out of our calculations for some years to come.

The remaining source of danger is the La Grange mine, which is put down for an annual production of 2,031,000 yards of detritus, and has now been in full operation some eight years. Its workings are either directly at La Grange, dumping into the main river, or else at some distance from it, dumping into an extended series of ravines, which have their common outlet in a very narrow gorge. From a special survey I am able to very closely estimate the quantity which has gone directly into the stream at La Grange as 5,000,000 cubic yards, or less than 700,000 yards a year. Since this represents less than three years' work for the water supply of the mine, it follows that much the larger part of its waste has gone into the ravines above mentioned, and it has so effectually stored itself in them that all the best and deepest claims are now abandoned for want of grade.

The narrowness of the outlet has made it an almost perfect dam; so much so that, though the water on issuing comes upon a low and cultivated bottom, we find there only a very slight deposit of sand and no coarse material.*

Supposing 30 per cent. to escape, we shall have, for the average yearly burden of the Tuolumne, very nearly 1,000,000 yards as against more than 2,000,000 given in the summary for the Calaveras, a stream of only a quarter the drainage area and discharge, and already badly choked with *débris* throughout its own and tributary cañons.

STORAGE.

The main object of the instrumental part of the season's work was the location and study of sites for the storage of mining *detritus*.

Looking at the matter from a simply topographical stand-point, the Cosumnes, Calaveras, and Dry Creek furnish admirable facilities for this purpose; while for the Mokelumne, Stanislaus, and Tuolumne, from the height and narrowness of the bordering bottom-lands, and their much greater discharge, this is not at all the case.

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* This peculiar topography and its results are plainly shown in the plane-table sheets of La Grange and neighborhood.

In making the choice of a site on any river, we are presented with two alternatives—a high dam of rubble stone in the foot of the cañon, or a lower one of brush and gravel where the valley spreads out below in the hills.

Were we limited only by the general consideration of safety, certainly, in securing the desired end and a form of construction justified and assured by precedent, it would only be necessary to go down from the foot of the cañon to the first place where a low dam of reasonable length would close a sufficient storage area above. But, unfortunately, in the present state of affairs, on all the southern rivers this plan would be rendered inordinately expensive by the damage which would thereby be caused to property.

On the Yuba and the Bear the outflow of mining *débris* has laid waste the sites best suited for storage reservoirs and made their construction simply a matter of building the required dam. Even on these their position has had to be modified by other than simple engineering requirements to avoid taking in cultivated tracts, now precariously protected by levees, and whose destruction is apparently not far distant. But in the south, where hydraulic mining has been and is on a much smaller scale, and where its bad effects are as yet comparatively undeveloped, the lands best adapted, topographically, for storage, though somewhat damaged, and perhaps seriously threatened for the future, are now the most cultivated and valuable in the country. Only on the Cosumnes, Dry Creek, Mokelumne, and Calaveras have the farmers been driven here and there to throw up light levees, and even in the extreme upper part of these valleys unprotected bottom lands are still held at from $50 to $100 per acre.

Turning to the other alternative, a high dam in the cañon, with all its inherent disadvantage, we are met by another obstacle in the presence at the foot of these of some of the chief hydraulic claims, thus making it necessary either to leave the principal source of supply unprovided for in the way of storage, or else to secure this and ruin the mine, at the same time, by choking up its dump.

To fully develop the points thus generally stated would require detailed descriptions in each case and the result of calculations which it has not yet been possible to make; but to illustrate some of them more clearly, I have prepared the following table of storage capacities. The figures in it only include projects for the Cosumnes, Calaveras, and Dry Creek, the drawings of the sites on which have been sufficiently advanced to admit of the necessary estimates being roughly made.

For the Mokelumne, Stanislaus, and Tuolumne this is not the case, but it can be said of them that the dams will have to be of much greater size and strength to raise the water over banks from 15 to 20 feet in height, while the areas thus made available for storage will be quite limited in extent.

The plane-table sheets herewith transmitted will cover the ground sufficiently to clearly show this, as well as to fix in position the most advantageous sites, for which special estimates and drawings will be submitted hereafter.

TABLE III.

Estimates for reservoirs.

Items.	Cosumnes.	Dry Creek.	Mule Creek.	Sutter Creek, high stone dam in cañon.	Ione Valley.	Buena Vista Valley.		Calaveras.	
						North dam.	South dam.	East dam.	West dam.
Bottom land covered......acres..	1,144	246.0	151.6	36.0	2,424	162.0	288.0	175.0	506.0
Upland covered......do...	322	34.0	39.7	29.0	334	48.0	81.0	65.0	202.0
Value of land covered......per acre..	$80= $177,280	$100= $28,000	$100= $19,130	$100= $6,500	$100= $275,800	$100= $21,000	$100= $36,900	$80= $19,192	$80= $56,640
Length of dam......feet..	1,000	3,200	2,000	300	1,600	1,400	3,700	900	700
Maximum height of dam......do...	12	11	7	20	13	15	15	12	20
Mean height of dam......do...	7	5.4	5.1	16.7	6.1	5.7	5.4	5.5	7.1
Cost of dam......per linear foot..	$12.50= $12,500	$12.50= $40,000	$12.50= $25,000	*$1.50= $25,500	$12.50= $20,000	$12.50= $17,500	$12.50= $46,250	$12.50= $11,250	$12.50= $8,750
Material impounded......cubic yards..	11,014,500	2,689,000	1,444,000	1,500,000	22,370,500	1,542,500	2,621,200	1,413,500	4,405,000
Annual amount to be provided for, 70 per cent. of total production......cubic yards..	782,000	283,500	26,600	703,675	1,013,200	119,800	119,800	1,564,065	1,564,065
Number of years required to fill reservoir......	14.0	9.5	54.0	2.1	22.7	12.9	21.8	0.9	2.8

* Per cubic yard.

REMARKS ON TABLE III.

The State engineer takes 70 per cent. of the material moved as the quantity for which storage should be provided, regarding the remaining 30 per cent. as being carried off in suspension. I do not doubt that this is an excessive estimate, since great masses of detritus stay permanently in ravines far away from the main rivers. At the North Hill Claim, near Jenny Lind, for instance, probably 50 per cent. of the product will store itself in Rich Gulch.

A close calculation is impossible without going into a detailed study of each case, and, as it is better that the figures should be over than under the truth, the State engineer's proportion has been used for the table.

The estimate for Ione Valley perhaps needs explanation. This is a triangular-shaped basin into which Suter, Mule, and Dry creeks enter, at somewhat widely divided points on the base, to join near the vertex in a single stream called Dry Creek, and immediately after break through the inclosing line of hills in a narrow cañon. In the broader part of the valley these creeks are separated by two projecting tongues of upland, and the storage dams for Mule and Dry creeks are planned as joining the tips of these in the first case, and the western one to the hills in the second.

A similar arrangement for Suter Creek was out of the question, since the town of Ione, just at the mouth of the cañon, would thereby be included in the site, so a high rubble dam above was substituted.

Finally a dam has been estimated for to take in the whole valley, which would eventually make necessary the protection of Ione by levees. The fitness of the latter site for storage, were the land available, is shown in the fact that a dam 1,600 feet long would cover 2,758 acres, or between 4 and 5 square miles.

On the Calaveras again, we have a dam only 700 feet long shutting up near 700 acres.

GENERAL CONCLUSIONS.

The following is an outline of the facts as they appear to me, and the conclusions which seem to be justified by them.

As might be expected from the fact that auriferous gravel deposits diminish in extent and value as we go south from the Yuba and the Bear, hydraulic mining presents itself upon a comparatively small scale along the rivers which are the subject of this report. Such mining has been heretofore more extensive than it is now, and, in the failure of unforeseen and unexpected developments, this decrease may be expected to continue.

The topography offers good opportunities for the storage of even much greater quantities of detritus than are at present to be feared on the Cosumnes, Dry Creek, and Calaveras, but the cost of occupying the sites would now be excessive, from the value of the lands which would thereby be destroyed.

Similar facilities are not to be found on either the Mokelumne, Tuolumne, or Stanislaus; but it may be said of the latter that there is no present reason for fearing its further injury by *débris*, and therefore none for considering its storage capacity.

It is probable that the harm to the navigation of the San Joaquin from the sedimentary load of the Mokelumne and its tributaries has been greatly lessened by the spreading out of that river, in flood, over the low tule-land near its mouth, and the same is true, to a lesser degree, for the Calaveras.

The greatest danger now to the same navigation is the million yards waste material thrown annually into the Tuolumne; but of this quantity probably not more than half would be coarse enough to be held back in storage reservoirs, and it is probable that the harmless transport of the entire burden could be provided for by measures on the San Joaquin itself.

In the absence of reliable early information about the San Joaquin, I am unable to say what deterioration it has undergone, but am inclined to believe that, while considerable deposits have been made over the tidal areas of its lower course, its ruling depth and head of navigation are substantially unchanged.

The damage thus far done may therefore be approximately summed in the injuries to farming land, which will go on increasing, while the total ruin of much of it is inevitable in the near future. Greatly as this is to be regretted, it is also true that the first destruction will be in those places which are most needed for storage, and that meanwhile every acre overflowed is doing its part as a settling reservoir for the protection of the San Joaquin.

Without denying that it may become expedient for the United States to undertake works in these valleys for the protection of the main stream, it seems that these should be at least preceded by such leveeing and clearing of channel ways for the safety of adjacent land as is hardly in the province of the general government, and has yet scarcely been begun.

Finally, the repetition of such a catastrophe as the flood of 1861 and 1862, in the present choked condition of the cañons on some of the southern rivers, notably the

Calaveras, might at a blow bring about such a change in the existing state of affairs as would necessitate an entire reconsideration of the question.

By your direction, I left the city on November 29, and made an examination of the dams lately built on the Yuba and the Bear; the ground covered by the survey of the American; the Feather, near Oroville, and the mine at Cherokee Flat, with its dump on Table Mountain Creek.

On my return, on December 6, a party was sent with your approval to Oroville to make a hasty survey of a reservoir site for the storage of the detritus from the Cherokee Flat mine. A week was spent in this work, which does not cover the ground as I could wish, but will admit of a tolerable estimate of capacity being made.

Of the Feather and American I can only say that my impression, formed from a necessarily superficial knowledge, is that they do not offer good facilities for storage, from their topography, the height and value of the bordering alluvial lands, and the difficulties which would be met in attempting to dam streams of such considerable size.

The mine at Cherokee Flat is one of the largest and most important in the State. It uses 2,200 inches daily throughout the year and, from the fineness of much of the material worked, the product of *débris* per inch used is very large—probably 4 to 5 cubic yards. The dump is down Saw-mill Ravine into Table Mountain Creek.

Immense masses of the coarser gravel and cobbles lie near their junction, while below the finer detritus is spread out to a considerable width for some 4 miles to the Chico Road.

Westward of this the uplands, by which the lateral spread of the tailings has thus far been limited, disappear, and the mining company, to avoid trouble with the farmers, has built two lines of levees, generally following the course of the creek for some 20 miles, and bought also the greater part of the adjacent land from the end of the levees to the tules in the northern part of Butte Basin. They have also built a low dam, about 4,000 feet long, just east of the Chico Road and acquired possession of the land on both sides of the creek from the dam up to their dump. This dam is a light bank of earth some 4 or 5 feet high, one end joined to high ground, the other left out in the air; nevertheless it has served a good purpose and stored a large mass of material.

Above it some three-fourths of a mile is another site, which seemed to offer better advantages, and it was to develop these that the survey was made. It shows that a dam 1,460 feet long, with a maximum height of 5 feet, would store 3,496,000 cubic yards, supposing the retained material to lie on the slope which it now has at this place.

A theoretically perfect disposition of the waste product of hydraulic mining would be to store its coarser part high up near the dump and to pass the remainder in suspension through a leveed channel, into a wide settling basin from which the cleared water might issue to the main streams. Nature has provided the latter part of this arrangement for the mine at Cherokee Flat, and it only remains to occupy a very favorable reservoir site and maintain levees already built to make its future operations a benefit rather than a harm.

The levees of the company have not hitherto been satisfactory, since, being of adobe, they separated into deep cracks in summer to give way under the pressure of winter floods.

A remedy for this state of things has been applied with good results for near 7 miles of the canal, and is being extended as fast as possible.

The plan is to throw up a "sublevee," only 2 or 3 feet high, outside each of the main levees. Through the two ditches thus made the drainage of the mine in summer is carried, keeping the main embankment wet and also causing a deposit which, from time to time, is thrown upon them by hand.

At the time of my visit to the Yuba and Bear, three days' rain had caused quite a rise in both the streams. Behind the dam on Bear River a large body of water was pent up and slowly oozing through for nearly the whole length of the work. None of the escape, however, seems to be under the mattress of the foundation, and though here and there it was concentrated in streams of some volume, none seemed of enough size to threaten danger. Below the dam most of the water was running along the north bank, and in one place had badly undermined the guard levee placed on it. It was plain to the eye that large deposits of *débris* were being made in the reservoirs and on the foot of the dam.

On the Yuba the water in the reservoir was raised in level at least 2 feet; but near the north end of the dam there was a depressed portion, of perhaps 25 yards in width, over which it was draining off in a torrent, which fell with great violence on the apron below and seemed to threaten the safety of the entire structure. At first sight this looked like a break; but a close inspection showed that not a stick had gone out of the dam, which, though badly squeezed, was perfectly intact, notwithstanding the rudeness of the test to which it had been subjected. It was also noticeable that, though there was necessarily a strong current along the up-stream side to supply the volume pouring over the low part of the dam, there was a recent deposit, nearly out of water, opposite and not over 100 feet above this point.

While, as before stated, there was an escape all along the Bear River Dam, the one along the Yuba seemed to be holding the water back more effectually, and, save at the gap, the bed of the stream below the work was nearly dry.

Respectfully submitted.

A. H. PAYSON,
First Lieutenant of Engineers.

Col. G. H. MENDELL,
Corps of Engineers, U. S. A.

I. REPORT OF LIEUT. A. H. PAYSON, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
San Francisco, Cal., January 8, 1882.

COLONEL: I have the honor to transmit herewith a supplementary report upon the results of the surveys made by me, under your direction, during the summer of 1880.

GENERAL SURVEY.

The object of the surveys being the selection and examination of sites suitable for the storage of detritus, they were only in detail at such points, and limited elsewhere to a transit and level line, which usually followed the cleared upland, and was supplemented by notes of the appearance of the valley and occasional cross-sections, to determine its general form and slope. Favorable tangents of this line were marked in a semi-permanent way by redwood posts and frequent bench-marks, established descriptions of which will be found in the transit and level notes, respectively. Corrections with United States land surveys were also made when practicable.

Over portions of the river where storage seemed possible, the transit meander was carried upon both upland banks, tied across by cross-sections, and the stations afterward occupied by the plane-table, by which grade lines, generally 20 and 40 feet above low water, were located and the general topography sketched.

These more detailed surveys have alone been platted on the sheets submitted with my report of January last, while the general transit lines have only been used in preparing the profiles and cross-sections sent in at the same time.

The large maps were made by first plotting carefully the transit and level notes, and then fitting the plane-table sheets to them. Hence they are in their general outline more accurate than the sheets themselves.

The general results of these examinations, and the inferences based upon them, having been already presented, the object of these memoranda is only to collect the fragmentary information scattered in my daily journal, and to place in a connected form the record of the work while in the field.

I may say, further, that previous efforts at storage of detritus in California had directed my mind toward seeking opportunities for it at the heads of the valleys proper, as distinct from the so-called cañons. Moreover, the position of the chief mines along the southern rivers being in the lower edge of the foothills, the last-named sites would furnish only a partial solution of the question. Hence the surveys extend only a short distance into the cañons, and no information was collected about them more precise than could be gleaned from hearsay and personal examination at a few scattered points.

COSUMNES SURVEY.

The transit line began at the north end of the railroad bridge across the Cosumnes at McConnell's ranch; the reference of the initial point having been furnished by the railway office. It was thence carried partly in and partly along the north edge of the bottom 1½ miles, to the junction of the Cosumnes and Deer Creek; at this point the river crosses to the south side of its valley, but the line was kept on up the right bank of Deer Creek, the country being less difficult, and the streams not being separated by any divide.

At the Slough House it crosses and leaves Deer Creek to gain the right bank of the Cosumnes on the southern tip of the upland divide, which here makes in between them just east of Howell's store; thence along the same bank to Michigan Bar, 22 miles from the point of beginning. The detailed surveys cover the ground from Michigan Bar to 2½ miles below Live Oak Bridge, to include a wide extension of the valley, closed at its lower end by a narrow gorge.

The total work was 222,925 feet of transit and level line, followed by plane-table for 58,314 feet, and there were employed fourteen working days from August 25 to September 9, inclusive.

Description.—The Cosumnes Bottom at the railroad bridge is about a mile in width and from 5 to 8 feet above the low-water surface. The greater part of it is covered by a dense thicket of young willows, overlaid by particles of coarse micaceous sand, or cut up by high-water channels; some yet remains clear, however, save for scattered oaks and cottonwoods of considerable size, and is still cultivated. On either side of the bottom is a rolling upland of red gravel, perhaps reaching heights of 50 feet in places, but for large spaces near the border so low as to have been overflowed by floods of late years for from one-quarter to one-half mile out from the bottom proper. Where this has taken place the land so covered is left with a thick coat of sediment and its quality improved, becoming in three or four years fit for corn instead of very indifferent wheat. In this way hundreds of acres of good land have been made since 1861–'62, chiefly on the south edge of the valley. This covering of the upland by floods, evidently a comparatively recent matter, indicates their increased height, and is also a partial compensation for the ruin of most of the original bottom.

The divide between the Sacramento and Cosumnes drainage system is close to the latter, but is generally so ill-defined that it cannot be picked out by the eye, and is probably not over 20 feet above low-water surface.

These characteristics are generally preserved as far as Elder's ranch, 9 miles above the bridge, though the damage done the bottom by floods gradually diminishes and the amount of land under cultivation increases. The actual bed of the stream is a tolerably coarse sand, overlaid by a thin crust of brown sediment ("slickens"), and closely follows the north edge of the valley, 1½ miles, to its junction with Deer Creek. Formerly this junction took place 7 miles below the railroad bridge, and the main Cosumnes stream kept close to the south side; but in the past five years it broke out of its old bed and cut its way directly across to its present course in the former bed of Deer Creek. From the junction up to where their valleys separate, near Howell's, Deer Creek and the Cosumnes follow quite closely the north and south borders of the valley, respectively. The Cosumnes being the larger stream, and the main agent in the formation of the bottom, the land on the south side is higher and slopes gradually down to the banks of Deer Creek, as is shown on the cross-sections. Hence, when the floods break out from the former, they rush over the land between with destructive effect, and enough velocity to carry and spread over it the large patches of coarse sand which are everywhere met with. Some idea of the extent of this action may be formed from the fact that at Elder's ranch, close to the north upland flank, was a pond fed by springs nearly one-half mile in length, and in places 26 feet deep. It was completely filled with sand by the flood of 1879, so that not a vestige of it now remains.

Above Elder's ranch a line of low rolling hills begins on the north; on the south the uplands also become higher and the slopes toward the bottom from both become much more abrupt.

The width and appearance of the bed of the Cosumnes remain the same, but a marked change for the better appears in the bottom land, which is higher, more open, less damaged by sand, and under a fine state of cultivation.

Above Howell's store (79,500 feet by transit line from the railroad bridge) high land makes in between the Cosumnes and Deer Creek, and their valleys widely diverge. The former river here flows through a gorge where the upland banks, from 70 feet to 90 feet in height, with extremely steep slopes, come to within perhaps 1,400 feet of each other, with only a narrow strip of bottom on the south side of the channel. Above, the valley again widens out to from 1 mile to 1½ miles, and we have in this widening and the land just below Howell's the finest, best cultivated, and least injured part of the valley. About 1¾ miles above this gorge is another, at which point the plane-table survey begins, and above which the valley is mapped to Michigan Bar. Between the first wire bridge and Howell's store the water way of the Cosumnes undergoes a striking change. Below it had usually been in one channel between quite high and well-defined banks, and the actual sand of the bed always overlaid by the fine brown "slickens."

Above, it is cut out to excessive width; large deposits of sand appear in it and along the banks, while the water, in numerous threads, trickles rather than flows between the bars. At Howell's the original water-way is clearly marked by parallel rows of willows, not more than 60 feet apart, now apparently standing in midstream. Finally, when we come to the part of the valley in which the storage reservoir is planned, the bed has been substantially filled up by deposit, and we see for the first time on the higher bars gravel of the size perhaps of a walnut.

Since the coarser material is nearly always overlaid by the fine sediment left last by receding floods, it is impossible, without numerous borings, to discover the limits to which the various sizes of detritus are now carried down, though these indications may furnish some basis for future comparisons. Above the Live Oak Bridge the gravel in the bed rapidly increases in size, cobble points appear until a little over a mile above we reach the discharging point of the Hilltop mine, and the river becomes dammed up by an immense mass of coarse material. At this point the river assumes definitely the distinctive cañon features, and above Michigan Bar becomes a mere cleft between high rocky banks and nearly dry, the water before in it having mainly come from the operations of the mine below.

Slopes.—From the railroad to Live Oak Bridge the slopes of the river increase with considerable regularity from 3 feet to 11 feet per mile, as shown on the profile sheet. Above the wire bridge, as might be expected from the excessive mass of material thrown into the stream, these slopes are irregular, varying from zero just above the dump to 43 feet a short distance below Michigan Bar. The examination did not extend above, but from the slope, heights of discharge, and distance by the stream at which water was taken out by Jourdan's Ditch and that of the Amador and Sacramento companies, I estimate the fall in the next 16 miles as not over 30 feet per mile and probably nearer 20 feet.

Filling.—My estimate of general filling based on marks, which, at first, would appear reliable, is nevertheless liable to error, from the fact that a deposit in one place may have been excessive from local peculiarities, and accompanied at the same time by a constant level or actual scouring out in the near neighborhood.

The following facts noted on the Cosumnes, will, perhaps, illustrate this point:

From the appearance of many large trees in the vicinity of the railroad bridge the general level of the bottom land would seem to have been raised from 3 to 4 feet.

Near by in the depressions of the old wheat lands, now overlaid by sediment, stumps of white oak 2 to 3 feet in diameter were found buried flush with their top surfaces. As they must have been cut off 2 to 3 feet above the ground, a fill of that amount would appear to have taken place since, while they originally, of course were on higher ground than the bottom proper.

Mr. Elder, before 1861, built on his ranch a wheel to raise water from the river for irrigation. The wheel was 24 feet in diameter, which would make the bank over which it had been thrown, near 20 feet in height. It is now 12 feet. (C. S. No. 5.) The axis of the wheel is still in its old place, and levels showed its iron trunnions 5½ feet above the present water surface; as it originally was at least 11 feet, we have here a fill in bed of 5 to 6 feet.

A line of borings was made along C. S. No. 5, on Elder's ranch. The original soil of these bottoms was a black adobe, quite plainly recognizable when unmixed with the more modern deposits.

Close to Deer Creek, on north edge of bottom, this black soil was found at 2 feet below the surface. This does not indicate the same amount of fill, since the top lighter colored layer is, of course, formed, by the mixture of the older, and more recent materials.

The other borings gave about the same result, though in several places nearer the Cosumnes no black soil was found at 3½ feet.

Just below the line of the C. S. was last winter's break in the levee, which had formed a deep arroyo extending back into the bottom, along the bank of which the line of division between the two soils could be clearly traced for more than 200 feet, indicating an average fill of about 2 feet.

At Lower Wire Bridge a reef of rock twenty years ago stood out of water for a height, as variously estimated by several old residents of from 6 to 10 feet. It is in the present bed of the stream, but is completely covered by deposit.

Just below C. S. No. 9 (foot of storage reservoir) a white oak 3 feet in diameter stood in the bed of the river, and was buried to within 4 feet of the branching of its limbs.

Supposing this branching to have originally been 15 feet above ground, and the latter to have been 5 feet above low-water surface, both extremely moderate estimates, considering the size of the tree, and we have here a raising of the bed of 16 feet.

Live Oak Wire Bridge was built in 1862, after the original wooden one had been carried away by the great flood of that year. The floorway of the old bridge was 16 feet above the low-water surface, and from the approaches which still exist, it seems probable that the river bed is now 4 to 5 feet above the floor of the old bridge. This result is made probable by the testimony of several people who have been in the neighborhood since 1849, and also by the appearance of the banks, the deposits here being quite level with their tops.

Mr. Plummer, a very intelligent man, and the owner of the finest farm in this part of the valley, showed me places where the lower parts of his land had been raised from 1 to 2 feet by sediment and thereby changed from marsh to productive fields; and while he had no doubt from his own knowledge that the river bed at the wire bridge had been raised about 20 feet, he pointed out one curious anomaly illustrating the remark made above. Seven years ago he felled a dead white oak that then stood in the water-way of the river. It was cut off about 2 feet above the ground and still stands with the same height.

On the foregoing facts I assumed, in my report of last year, a fill of 6 feet 8 miles above the railroad bridge, 15 feet 17 miles above, and 20 feet at entrance to cañon, and computed the amount of material which this would correspond to between the railroad bridge and cañon, giving an average width for each section.

Land damage.—When the original black soil of the bottoms is overlaid by the finer sediment, its quality and capacity for retaining moisture are improved; while the originally nearly worthless red gravelly soil of the upland, when so covered, is in a few years made fit for the production of fine fields of corn. Leaving out the land just at the mouth of the cañon, the worst of the damage so far done along the Cosumnes is near the railroad bridge; yet the settlers below Elder's seemed generally to think that they had thus far received more good than harm; that is that the improvement of the old bottom land and the forming of new had more than made up for the damage by sand.

When sand is swept over the land its limits though at first well defined, in a year or so become almost indistinguishable by mixture with the other soil. Covered as the land is also by growing crops in summer, it is extremely difficult to get even an approximate idea of the amount of harm which had been done.

By asking most of the farmers on the bottom lands below Elder's, I gathered that, owning, as most of them did, from 100 to 160 acres of it, their estimates of the area sanded would vary from 5 to 10 acres (3 to 10 per cent).

A pretty correct estimate for Elder's ranch gave 7 acres now unproductive, though not of course permanently ruined. Above Elder's a short distance one very considerable deposit of sand occurs brought in eight years ago. It probably covers 100 acres, and in low places is 5 or 6 feet in depth.

Above this again to C. S. No. 9 (foot of storage reservoir) very trifling damage seems to have been done the land, which, is about Howell's and the Slough House particularly, is in splendid order and highly cultivated. In many places about here the original black soil is still turned up by the plow.

The state of things in the valley selected for survey as a storage site is pretty well indicated by the maps and cross-sections.

Quite a deposit of sand is found, as might have been expected, just below the wire bridge, chiefly on north side of the river.

Plummer's ranch, farther down on the south side, is but little harmed. The total area of bottom land between C. S. 9 and wire bridge is 1,144 acres. Of this I believe 300 acres at least are buried by sand 1 to 4 feet deep over it, and much of the rest is more or less damaged.

Above wire bridge there is practically no bottom land to injure.

Price of land.—The wheat lands on both sides of the Cosumnes, between railroad and Elder's, are assessed at $15 to $20 the acre. The bottom lands in their present condition are held at $20 to $35. About Howell's and Slough House the bottom land is valued at $100 per acre. Above Howell's the upland becomes very poor, the bedrock coming close to the surface of the red gravelly soil. It is useless save for feed; but for that, and as giving access to the bottom, it is held at from $2 to $7 per acre. In the basin of storage reservoir the bottom land has always been held at $75 to $80, but no recent sales have been made at those prices.

Floods.—Before 1861–'62 no damage was done by the floods; the waters of the river were clear, very seldom overtopped the banks, and then only for short periods. Since that year the floods have constantly increased in height and destructiveness. They generally take place in February and March, but the flood of 1879–'80 was on the land in April, and staid so long that the corn crop, which is the chief one in the valley, did not have time to mature. Many of the farmers asserted that this flood was higher than that of 1861–'62. All were positive that it was quite as high. Many flood marks left by drift of last season were taken during the survey. The results as are follows:

At C. S., 3 mark, 7.5 feet above low-water of Cosumnes.

At C. S., 3 mark, 12.1 feet above low-water of Deer Creek.

Water surface of Cosumnes nearly 5 feet higher than that of Deer Creek.

At C. S., 4 mark, 8.9 feet above low-water of Cosumnes.

At C. S., 5 mark, 6.45 feet above low-water of Cosumnes.

Half a mile above C. S., 5 mark, 6.5 feet above low-water of Cosumnes.

Half a mile above C. S., 9 mark, 13 feet above low-water; this is in the gorge at foot of proposed storage reservoir.

At C. S., 11 mark, 6.5 feet above low-water of Cosumnes.

At Live Oak Bridge mark, 5.84 feet above low-water of Cosumnes.

One mile below Michigan Bar mark, 14.45 feet above low-water.

Just below Michigan Bar mark, 14.15 feet above low-water.

The following are the references of the zeros of two gauges of the S. E. D.:

Below Live Oak Bridge (140.6).

1,900 feet above same bridge, right bank (142.4).

Ditches.—There are three mining ditches whose water is used in the Cosumnes.

1st Eagle Ditch.—Takes water out of the river from right bank 6 miles above Michigan Bar; is 12 miles long and discharges opposite Michigan Bar, about 75 feet above low-water; built for 300 inches, but does not now carry over 200. Supply lasts from seven to nine months in each year, and is all used for mining by the owner in various small claims.

Empire Ditch.—Takes water out of the South and Middle Forks of Cosumnes, the ditches joining at Plymouth.

The water is first used in quartz mills at this point, chiefly in the Empire Mine, which for power and washing requires from 700 to 750 inches daily. After being so used it drains into Indian Creek, and by an agreement with the Amador and Sacramento Company 400 inches daily is allowed to go down to their reservoir on this stream. For much of the time the quantity so sent down exceeds the stipulated 400 inches; in winter sometimes reaching 2,000 inches. When enough is left over the 400 inches to make it worth their while, the Empire sends off as much as possible of this remainder in a branch ditch, for use in small hydraulic claims about Irish Hill.

Amador and Sacramento Canal and Mining Company Ditch.—Takes water from the left bank of Cosumnes, 16 miles above Michigan Bar, to the Indian Creek reservoir. It was built for 1,500 inches, but does not now carry more than 1,000. Below Indian Creek reservoir the present capacity of ditch is 2,000 to 2,500 inches.

The length to reservior is 20 miles; to Hill Top Mine, 23 miles; discharges 115 feet above low-water.

All their water is used at the Hill Top Mine, which is on a ridge between the Cosumnes and Arkansas Creek, just before their junction. It drains in both directions from the crest of this ridge; but all the detritus finally gets into the river.

Some is sold for irrigation, but most of this comes back into ditch again, and then is used in mining.

The time during which they get a full supply, say 2,000 inches, is very variable; but will probably average six months in the year. They still had when I saw the ditch 1,400 inches in the middle of September, though this was later than usual.

These data are not so full as they should be, since I was finally disappointed in not receiving the figures promised me by the Amador and Sacramento Company, and was compelled to rely upon such information as I had been able to collect from outside sources.

IONE VALLEY SURVEY.

On September 10 camp was moved to near Ione, and on the 11th work there was begun.

The surveys, besides cross-sections, included a meander line along the entire rim of the valley, and the divides between Sutter, Mule, and Dry creeks, from which the topography was sketched by the plane table.

Levels were taken from a railway bench-mark at Ione Station.

In the gorge below Ione, where the three creeks above named are together, the plane-table work was discontinued and the transit line carried down the valley of Dry Creek to Jackson Creek, thence up Jackson creek to the lower end of its cañon where another plane-table survey was made of the upper bed of this valley. The transit line was then again taken up at the junction of Dry and Jackson creeks and carried down their united valley about five miles farther to Swift's ranch, which was reached on September 25. The following is a summary: Thirteen and one-half working days. Transit and level line, 204,960 feet. Followed by plane table 125,399 feet. The plane-table work has been plotted in one large sheet for Ione Valley and a small one of head of Jackson Creek. The transit meander has not been plotted, save when followed by the plane table; but from the level notes, three sheets of cross-sections and a longitudinal profile have been prepared.

Description.—Sutter, Mule, and Dry creeks all leave their cañons for the first time in Ione Valley, a fertile, highly cultivated piece of ground, containing some 2,400 acres.

The hills around are high and rise steeply from the flat alluvial plain, while from them run out two tongues of low upland, forming the extensions of the divides between the three streams. The low land is generally cleared, save along the edges of the creeks, where a dense growth, chiefly of willow, is found. In the lower part of the valley the three streams come together; are thenceforth called Dry Creek, and break through the rim of hills in a cañon only 1,600 feet wide, and choked with a dense thicket of willow and cottonwood.

Below, the bottom widens out again and is well cleared and cultivated till we reach the junction of Dry and Jackson creeks, 5.2 miles below the cañon. From this point to the foot of Jackson Creek Canon, at Buena Vista, is 7.1 miles; the valley is from 1,500 to 2,000 feet in width, cleared and nicely cultivated, at Buena Vista especially, where it opens out to a beautiful bit of land some 4,000 feet across. The bordering hills, like those around Ione Basin, are high and steep, with rock cropping out from their sides in large masses; sparsely grown with small oak, and good only for stock-raising.

Below the junction of Dry and Jackson creeks the bottom becomes very narrow, from 800 to 1,500 feet between upland banks; which gradually become lower, better in quality, and begin to be used for grain.

At Swift's Ranch, the end of our transit line, the hills, after having been 2,000 feet apart just above, come abruptly to within 700 feet of each other, forming a marked gorge, which, gradually getting slightly wider, continues for near 2 miles, when the high lands suddenly recede to right and left, and the stream comes out on the San Joaquin Plain.

The bottom, so called, spreads out to perhaps 2 miles in width, till 4 miles farther on, abreast of Hawk's Corners, the distinction between it and the upland practically disappears, and wheat is grown out to the banks of the creek, which are from 8 to 10 feet in height, and carry large oak timber.

Near Galt, about 7 miles below Hawk's Corners, several separate parallel depressions in the plain carry off the floods. The chief of these in which the low-water discharge is found is a torn and sanded strip some 100 yards in width, densely grown with willows and some larger trees.

Present state of bed and banks.—The grades on all these creeks, as shown in the sheet of profiles, are very heavy, increasing from 8 feet to the mile at Swift's, to 30 feet and 40 feet in the cañons. Owing to this the material carried is very large in size.

The following are remarks in my note-book. Where it enters Ione Valley the beds of Dry Creek and its tributary ravines are filled with enormous masses of course gravel and cobbles, resulting from the mining near Irish Hill. Most of this deposit is old, however, and, in the ravines, fixed by a growth of willows and even oak of some size. The heaviest dumps from Irish Hill are now on the other side of the divide, and the drainage is into a nearly bottomless country toward Buckeye.

Below the dumps the bed of the creek has been practically obliterated by a broad mass of gravel and cobbles (some pieces as large as an orange), and its level probably raised from 6 to 10 feet to below McDonald's Ranch—the limits of this gravel body being shown on the map.

McDonald's place was ruined in 1861–'62 by being covered with sand; but has since been steadily improving. The soil is yet sandy, and only fit for hops. Before 1861–'62 Dry Creek kept close to the west edge of the valley, and the crossings of its old bed at the highway and railroad appear on the maps. In that year it suddenly broke through in its present course, which it has since kept.

Between McDonald's and the "Q" ranch the bed remains of coarse gravel, but narrows to from 100 to 150 feet.

The ranches on both sides have been badly sanded, and in places there are on them patches of gravel the size of marbles. Below "Q" ranch the bed remains unchanged; the land on the west becomes higher and better, and has not been flooded since 1861–'62. On the east a good deal of sand lies in streaks and patches, but how much is very difficult to estimate.

Below Winter's, in the corner where the three creeks come together before entering the second cañon, the damming up caused by the narrow pass, badly obstructed by thickets, and helped by the long railway embankment with only short trestles over the beds of the streams, has practically ruined the land.

Each year the water-ways are becoming more choked with growth, and the evil is extending higher up the valley. Here and there a farmer exerts himself by cutting out willows and plowing up the bed, but soon becomes discouraged for lack of co-operation, and lets things take their course. When I was there the railroad had begun to lengthen their trestles in the hope of improving the state of affairs.

Their profiles showed no appreciable raising of the beds of the creeks since the building of the railroad.

Below the cañon to the Ione Galt road the bed is still of gravel, though perceptibly finer, and the ranches in fair order, especially on west side; those on the east somewhat sanded.

At this road sand begins to appear in the bed (though it is mainly of gravel to the end of our line), and a good deal of damage has been done the land for 3½ miles, caused by the narrowing of the valley at Swift's. Through this narrow part and below in the fine wide bottom to Hawk's Corners very little harm has been done, and probably very little change has taken place in the original conditions of the stream and banks.

Mule Creek.—The whole country near the abandoned mining camp of Muletown has been heavily washed; the ravines entering the valley of the creek are filled apparently to great depth with masses of coarse detritus, and the bed of the stream as far down as the crossing of the Ione and Sacramento road is practically a mining dump. Below this road the valley widens, the bottom is higher and the land in good order.

At Viollet's Ranch, near the junction of Mule and Sutter creeks, where they are only a few hundred yards apart, the bed of Mule Creek is coarse gravel, the banks only 20 inches high, and large areas of the bottom are covered with coarse gravel and sand.

The owner estimates his loss from last year's flood alone at $2,000.

Sutter Creek.—Along the bed of Sutter Creek the land seems now all in good order. In the future prospects of mining, however, this creek is the most threatened of the three.

Jackson Valley.—The bottom lands here are also in good order, though some have been ruined by sand just above Jackson School house on Dillon's Ranch, and in the upper end of valley near Buena Vista.

The remarks appended to the C sections give a good idea of the present state of affairs.

High-water marks.—No reliable high-water marks were seen in Ione Valley. The following are the only ones obtained:

High-water mark drift at Jackson School-house 9.14 feet above the present dry bed of creek.

Not quite 2 miles above School-house, in Jackson Creek Valley, a high-water mark was 5 feet above dry bed of creek, and 12.6 feet above some escape mining water close to the upland on south side.

A little more than 2 miles below School-house, high-water mark 9.5 feet above water flowing in Dry Creek.

The greater part of the damage done along all these streams was by the flood of 1861-'62, and no succeeding one has compared with it in height and violence.

Ditches and mining—Amador Canal Company.—The main ditch of this company takes water out of the upper portion of the Mokelumne and is supplemented by a reservoir formed in the Blue Lakes. It is 45 miles from the distributing reservoir near the town of Sutter Creek to the dam by which water is taken out of the river, and 80 miles by river and ditch to the Blue Lakes.

The main ditch was built to carry 3,000 inches, and at the time of my visit was running about 2,000, not being, however, at its full capacity.

Ditch 6 feet wide at bottom, 9 feet at top, and 3 feet deep, grade 8 feet to the mile for both flumes and ditch.

The water is mainly used for power and washing in the quartz mills scattered along the Mother lode from Jackson to Drytown, and discharges into Jackson, Sutter, and Mule creeks. Only a very small portion is used for hydraulic mining, in small claims near Jackson.

Buena Vista Ditch.—Below the town of Sutter Creek the mining water which has been used in the mills and turned into the stream is taken out by a dam belonging to the Amador Company and sent over to the small gravel claims near Buena Vista. Capacity of ditch probably not over 100 inches.

Johnson's Ditch.—Takes water out of Sutter Creek below the Amador Company's dam, who are compelled by his water right to pass down to him the "natural water of the creek." The ditch capacity is 250 inches, which it gets for from seven to eight months in each year, and which is used in various small hydraulic operations along Sutter Creek and near Muletown on Mule Creek.

Volcano Ditch.—Takes water out of some of the upper tributaries of the Mokelumne; but since these run dry usually before the supply in the main river becomes limited, it does not interfere with the Amador Canal Company. Its capacity was 500 inches, but they were enlarging it to 1,000 inches, and this enlargement has since, I believe, been completed. This water is all for use at Volcano in hydraulic operations, which were briefly described in my report of last year.

Irish Hill Ditch.—This is a branch of the Empire Ditch, and so takes water which came originally from the Cosumnes. It gets it after it has been used in the mines about Plymouth, from the bed of Indian Creek, and its full capacity is probably from 500 to 600 inches. It is all used for about eight months of each year in various small claims about Irish Hill, and so drains into Dry Creek.

Dougherty Ditch.—This takes water out of Jackson Creek by a dam some 3 miles above Buena Vista, and is carried thence through the claims about Mount Ophir in the head of Jackson Creek Valley and then over the divide and across the Mokelumne in a suspension pipe, for use in small workings just below Launcha Plana.

Its supply is largely dependent on the waste water discharged into Jackson Creek by the Amador Company, and will average 300 inches for from six to eight months in each year. During the past year it has never carried less than 100 inches.

No attempt is made here to go into the grounds for the calculation of the amounts of water used in the various places in a year, the result of which was presented in my former report. I can only say that I cannot improve upon those results in the way of accuracy now. The elements of the question are complicated and variable, and it is necessary with such information as it is possible to collect to still make large assumptions in order to reach any conclusion. In making these assumptions, I have tried always to be upon the safe side of the truth, and I am, therefore, certain that the totals given in my table (1) are rather in excess of the truth.

Mining.—The only mine of any importance in connection with the object of these surveys is the one at Volcano. It is an experiment of the success of which good judges in the matter are doubtful, but in which considerable capital has been embarked by its owners. If it fulfills their expectations it will involve the deposit of a large amount of material in the bed of Sutter Creek, on which and the lands adjoining below it cannot fail to have a disastrous effect.

I have lately learned that the Volcano Mine after having been in operation but a short time stopped work, which has not so far been resumed.

Of the other hydraulic claims, Muletown, Irish Hill, Mount Ophir, and the operations of Chinamen along the beds and banks of the creeks, it can be said that they are now of very small importance and rapidly on the wane. Enough has already been done to prove a source of damage for a long time in future to the farming land, but considered only with reference to the navigable waters of the State, the present condition of this drainage system does not seem to call for attention.

MOKELUMNE SURVEY.

On September 25 we began a line transfering our levels from Dry Creek at Swift's to the Mokelumne, in order to do which it was necessary to cross between 5 and 6 miles of open, though high and rolling country. The river was reached on Monday, the 27th, and the line up it begun and carried to near the town of Launcha Plana. I had been away during these operations, but on joining the party, by your instructions, the survey on the Mokelumne was temporarily abandoned to be taken up on the more southern rivers, whose examination was considered of greater importance. Having some time to spare toward the close of the season, work on the Mokelumne was resumed on November 10, and finished November 16. As a result we have a plane-table sketch of the river for more than 12.6 miles beginning well up in the cañon above Launcha Plana and ending at the Athens Ford, near the Poland House. The sheets covering a portion of the stream, about 27,000 feet in length, below Launcha Plana, believed most important, have been transferred to a large map.

The following is a precise summary: Total length, transit, and level line, including cross-sections and the transfer from Dry Creek, 130,390 feet = 24.7 miles.

Plane table followed the transit and level line, 89,946 feet = 17 + miles.

Length of river covered by plane-table sketches, 66,646 feet = 12.6 miles.

Number of working days, 9.

Description.—Above Launcha Plana the Mokelumne is in a cañon with steep and rocky sides. At the town these, while keeping their general character, widen out here and there and the immediate banks of the stream become honeycombed with the remains of old and rather extensive hydraulic operations; some, however, of which are still worked during certain seasons of the year. For some 3 miles these continue after which the land between the banks of the stream and hills acquires more of the character of bottom, though generally from 15 to 20 feet above the low-water surface, and is under cultivation. The actual water way at low stages is from 150 to 250 feet in width; but the high banks are separated by from 500 to 800 feet, and the bed between them is cobble and coarse gravel without any sand. These features are generally preserved, though the bordering hills recede farther and lose in height till we get about 2 miles below the Athens Ford or 11 miles below Launcha Plana. Here we finally lose the high hills on the left bank, though they keep on for a short distance further on the right, and the bottom land begins to be of considerable extent and importance. The bed of the stream also undergoes a complete change. At the ford it is still, of coarse gravel, though showing large banks of sand, and some 600 feet across. In the bottom below the Poland House, on the contrary, the bed of sand and mud is perhaps only half this width between high banks, which are thickly grown and have entirely lost that appearance of being torn out by floods which is their distinctive character above. The bordering alluvial lands are still from 10 to 16 feet above low-water and highly cultivated. The finest land along the river extends from the Poland House down for about 7 miles or to 3 or 4 miles below Lockeford. Here the bottoms become narrow again, are each year overflowed, and, though here and there cultivated in patches, are practically given up to willow and cottonwood thickets.

At Lodi, 8 miles below Lockeford, the distinction between upland and bottom has disappeared in a plain, which slopes gently up from the river banks, leaving along each border a narrow strip, torn and sanded by its annual flooding, and covered with a dense willow growth.

At Woodbridge, 2 miles below Lodi, this strip is only 200 yards or so in width, and the whole plain is so low that the town is protected by levees. The line of tule came formerly to within 3 miles of Woodbridge, but has now by drainage, leveeing, and the raising of land by flood deposits been carried some 4 miles farther west.

Damage to land.—Above the Poland House the land is hardly to be called bottom, since its formation evidently dates from a time when the Mokelumne was a larger river than it is now.

From its considerable height and the excessive width to which the banks were torn out in 1861–'62, the water has not been over it altogether since that year. The damage to land has been limited, therefore, to the widths actually lost by incorporation in the river's bed. Below the Poland House the bottoms are said to be overflowed about three times in each five years; the original black soil appears generally overlain with sediment, and a good deal of damage has been done by sand; but so far I believe no coarser material. Though no continuous system of levees exist, short lengths have been built here and there for the protection of special points. Abreast of Lockeford I saw some 10 to 12 feet in height. As we go down the exposure to and damage by floods increase until, from 4 miles below Lockeford, the bottom lands are practically given up to their effects.

The following is quoted from my note-book, written there after a personal examination along the river from Launcha Plana to Woodbridge:

As a general impression the bottom lands of the Mokelumne, where of any value originally, are in excellent order, and I do not believe that the sentiment of the people would approve any expensive measure of relief. A sufficient improvement could probably be had in the present condition of the question by straightening and clearing the channels and the leveeing and protection of the banks.

That the bed of the Mokelumne, near the foot of its cañon, has been considerably raised is unquestionable, though an exaggerated idea prevails of the amount of this change.

Just below Launcha Plana a dead oak 2½ feet in diameter stands conspicuously in the bed of the stream. From the crotch to the gravel was 4½ feet; to low-water surface, 6 feet.

Allowing the original surface to have been only 6 feet below the crotch, the water-level has been raised the height of the original bank. I think a minimum estimate of this height would be 15 feet.

From marks shown me on the bank near Lockeford, an intelligent land surveyor had estimated that it had been filled 7 feet since 1850. The bed has risen more than this, since the banks are not as high now as then. Three miles below Launcha Plana a flume formerly gave, I was told, a head of 20 feet. The present height of its discharge point indicates a filling of at least 15 feet.

Just above Launcha Plana is a solid mill-dam, which has backed up behind it a great mass of gravel and cobbles; hence, most of the filling below has probably resulted from the mines at and near that point.

From the height and appearance of the banks below Lockeford, I should not suppose that any very marked change had taken place there.

Grades.—About 2 miles below Comanche the grades suddenly change. Below, from the Poland House, they are quite regular, increasing gradually from 3 to 4 feet per mile. Here they rise abruptly to 20 feet, and thence upward by their irregularity and steepness furnish a graphical illustration of the great burden of material which has been thrown into the bed.

High-water marks.—Just below Launcha Plana, water surface 150 feet, high-water mark (drift) 159.2 feet; difference, 9.2 feet. Above dam, water level 170.5 feet, high-water mark, 177.43 feet; difference, 7 feet. This was mud line on rocks, probably formed after a certain amount of fall.

Ditches.—Mokelumne and Campo Seco Canal Mining Company.—This is the most important. Takes water out of the South Fork of the Mokelumne by a dam about 2 miles above its junction with the North Fork.

The water of Middle Fork is also taken over the divide and allowed to fall by natural channels into South Fork just above the dam. The capacity of the main ditch is 1,000 inches. It follows the river for about 7 miles below the dam and then gets on the crest of the divide between the Mokelumne and Calaveras, which it follows to the distributing reservoir, near Mokelumne Hill, 16 miles from the dam. About three-fourths of a mile east of Mokelumne Hill the ditch divides; the smaller branch going around the head of Chile Gulch, the most northern tributary of the Calaveras, and along its southern divide to its junction with the Jesu Maria Fork of the same river. The larger ditch keeps on the crest of the northern or main divide through the town of Mokelumne Hill, and then, after sending off branches to the right and left for the supply of the Gwinn Mine and gravel claims at the foot of Chile Gulch, respectively, passes definitely to the north or Mokelumne slope of the divide, and is continued on to Campo Seco and Comanche. All of these branches were originally supposed to carry about 200 inches. Probably now that to the Gwinn Mine is the only one which does, this quantity being used there throughout the year for power and washing.

The supply actually received by the main ditch will average 1,000 inches, for eight months in the year, and in the remaining four months will reach a minimum of 300.

The company are now building a storage reservoir at Railroad Flat, in the head-waters of the Calaveras and Mokelumne, which will cover 80 acres, and insure a supply of 1,000 inches for the entire year. At the time of my visit this reservoir was completed to cover 40 acres, and was to be used the following winter. The distribution of the water between the drainage basins of the two streams varies very greatly at different times as the claims are taken up and abandoned; but at present the bulk of water used in the hydraulic operation goes into the Calaveras by Chile Gulch.

Clark's Ditch.—This is a private ditch, owned and mainly used by Clark, of Railroad Flat. It takes water out of South Fork of Mokelumne, and is equal to a supply of 200 to 250 twelve-hour inches for six months in each year. Generally its water goes into the Mokelumne, though sometimes it is taken across the divide and goes into Calaveras.

Murray Ditch.—Water taken out of the main Mokelumne, about 8 miles above

Launcha Plana. The ditch divides about 2 miles above Launcha. One branch crossing the river by a suspension pipe, is carried down on north bank to be used by Chinese, and in irrigation; the other keeps on south bank to Comanche.

The main ditch was originally built for 600 inches. It is now out of repair and probably, at the point of separation, does not carry more than 250, of which, about one-half goes each way. The owner of this ditch told me that it still carried near 600 inches, and was built for 700; but, from what I saw of it, consider my first statement more nearly correct. The supply lasts all the year.

Dougherty Ditch.—This has already been described. Most of its water is, however, used on the left bank of the Mokelumne, below Launcha. The Story claim there (shown on plane-table sheets) always gets 100 inches whenever the ditch will carry it. Whatever may be left is used at Mount Ophir and in various small claims along the line.

Mines.—The town of Mokelumne Hill lies among enormous deposits of gravel, much of which, however, is lava-capped, and only to be worked by drifting.

The water is delivered to the claims with good heads (150 to 250 feet), but the supply is very limited. The topography is such that most of these claims have their dumps on the Calaveras side, and as the result of long continued and extensive workings, have pretty well run out of grade. The condition would be entirely changed if these claims were considered of sufficient importance to justify the piercing of expensive tunnels, by which many of them might secure sufficient fall on the opposite or Mokelumne side of the ridge. One such tunnel is being built at what is called the Happy Valley Mine, the best and largest in the district. This tunnel will have to be 2,000 feet long, is now 300 feet in and will probably be finished. At the time of my visit the only mining operations in this neighbourhood affecting the Mokelumne were the Small claim, high up on its headwaters at Railroad Flat; and the Green claim on a northern spur of Stockton Ridge; or the main divide, just west of the town of Mokelumne Hill. The latter used 200 inches for perhaps half the year, and will be entirely worked out in a short time. I have left out of consideration the quartz mills of Knox and Osborn (twenty stamps), and that of the Gwinn Mill (forty stamps), whose drainage is to the Mokelumne.

Near Campo Seco, at Ragtown and elsewhere, we have other gravel deposits, which have been rather extensively worked, with small head and scant supply of water; but have now the appearance of being pretty well used up. And that they are so, seems the general impression in the community.

Most of them dump into ravines, pretty well removed from the main river, in which the bulk of their detritus is stored. None of these were in operation at the time of my visit. Below Launcha Plana, on the river bank, are remains of old workings on quite a large scale, and these, more than any others, have probably been effective in damaging the stream, since they have all dumped directly into it and depended on the winter floods for a renewal of their grades. The chief one of these is the Storey claim, which has been continuously worked by the same man for twenty-three years. With tail sluices on a grade of 1½ inches per box, he is yet only able to work off to within 15 feet of bed-rock, and, as the pay is mainly in the lower stratum, this has to be hoisted out in buckets and then washed.

The necessity for doing this shows plainly the reason for the abandonment of the adjoining claims, since only with exceptionally rich gravel could this plan be profitable. Near Comanche, at Poverty Ridge and Cat Camp, we find again workings which have nearly lost their importance. They all labor under the disadvantages of small heads, insufficient dump, and a scanty supply of water, and are only irregularly worked. Their dumps might all be improved by short tunnels into the bed of the main river; but it is doubtful whether such will ever be built; certainly not till the water supply is greatly improved. Much of the material from about Comanche has also been stored in ravines back from the river.

On the Mokelumne, the workings of the Chinese are more extensive than on any other of the southern rivers. Just below Launcha Plana they had diverted the entire low-water discharge, and were laying bare the old bed-rock; hoisting the material out and washing it. To sum up, it may be said for the Mokelumne that the damage by hydraulic mining has already been done; and that, failing expensive and unlikely changes in the drainage near Mokelumne Hill, no serious increase in thetrifling amount of detritus now thrown into the stream need be anticipated.

SURVEY OF CALAVERAS.

The party broke camp on the Mokelumne and moved to Jenny Lind on the Calaveras on September 30. On October 1 levels were taken from a railroad bench-mark at Milton Station and a meander line 3.1 miles connected it with the river survey. The latter extends from a point rather more than a mile above Jenny Lind Ford to Fisher's Bridge, a distance by river of 14.1 miles. For 2,500 feet below the head of the survey the meander and plane-table sketch included both sides of the valley, and the results have been transferred to the large sheet.

From the end of this to Fisher's the plane table was not used, the party being too shorthanded from sickness: and we have only a transit and level line down the right bank, with occasional cross-section; only the latter having been plotted.

The party on the 12th October was transferred to the Stanislaus; but, under instructions received later, it returned to Fisher's on November 17 and made a special survey of this locality, which for about a mile below the bridge is important as covering the point of separation between the Calaveras proper and Mormon Slough. The results of this have not been accurately plotted, but are transmitted on the original plane-table sheet.

Finishing here on the 19th, on the same day the party was transferred to Stockton to be disbanded.

The following is a precise summary:

First survey:

Total transit and level line, 136,460 feet = 25.8 miles.

Plane table followed transit line, 47,585 feet = 9 miles.

Lengths of special survey covering site of storage reservoir by river, 25,000 feet = 4.7 miles.

Nine and a half working days.

MORMON SLOUGH SURVEY.

Total length transit line, 26,216 feet = 5 miles.

Total length plane table and level, 44,977 feet = 8.5 miles.

Three working days.

Description.—Jenny Lind is just in the foot of the cañon of the Calaveras. Above for some 6 miles the river is in a narrow gorge, with steep rocky slopes on both sides, rising to a maximum height of perhaps 400 feet, and grown with chemisal. The bed is a jumbled mass of large bowlders, but, save in two or three places, where are the remains of old bars, seems swept quite clear of tailings. At the end of these 6 miles is the dam for the Jenny Lind Ditch, and at this point the appearance of the cañon undergoes a change.

The hills separate, become lower, clearer, and less rocky, and the bed contains an immense deposit of tailings, seemingly held back by the dam. These characteristics are generally preserved nearly to the junction of the North Fork with the South or Santo Domingo Creek, 6 miles above, and from 2 to 3 miles below San Andreas.

This dam was built in 1855, and, with the exception of two breaks before 1862, has stood continuously since, till the winter before my examination (1879-'80), when a small piece on the left bank went out.

Below is quite a large mass of tailings, evidently carried over the dam, which, however, extends for only a short distance, while above is a considerable pool, which the ditch-keeper told me was filled up each year, in low water, more or less with sediment, but scoured out again in the succeeding flood.

From the appearance of the cañon above and below the dam, I believe that it has been effectual in holding back a very large amount of material, and this idea receives confirmation from what I was able to learn about the slopes.

Between Jenny Lind and the dam the grade of ditch and height of its point of discharge above the bed shows a total fall of 307 feet, or 51 feet to the mile.

A preliminary survey, made some years ago for an extension of the ditch, showed, between the dam and the junction of South and North Forks, a total fall of 158 feet, or 26 feet per mile, and that the greater part of this was found in a sudden narrowing of the cañon at the upper end, while for the lower 4 miles the bed was a wide mass of tailings, with very light slopes.

These last statements I did not have the means of verifying, but they were made me by a very intelligent man, for many years the keeper of the ditch, and who assisted in the survey referred to.

The road through Murphy's, San Andreas, and Mokelumne Hill first crosses Santo Domingo and San Anton Creeks; then, to the north of San Andreas, the Calaveitas, Jesu Maria Fork, and Chile Gulch.

All of these are badly choked, particularly the two last, the cañons of which are filled up to a broad level bed of coarse tailings, bordered at intervals by nearly vertical banks of gravel, making the ends of numerous old and existing dumps.

At Jenny Lind are inconsiderable remains of hydraulic operations on the right bank, but on the left are immense deposits of gravel and cobbles, the result of twenty years of mining at Whisky Hill, the dumps from which are directly in the river bed.

Before the winter of 1879 and 1880 this great bank extended nearly across the stream, with a maximum depth of perhaps 50 feet, but the exceptionally violent flood of that season tore the larger part away and swept it down into the head of the valley, where its effects are seen in a mass of very coarse material, 800 to 1,000 feet in width abreast the town, entirely filling and obliterating the original bed, which in that year alone was probably raised from 4 to 5 feet.

The dumps have been left with nearly vertical banks, 20 and 30 feet in height, ready to yield a further enormous quantity to succeeding high water.

In the valley below Jenny Lind the hills, still remaining of considerable height, with lava outcroppings, recede to inclose a somewhat extensive valley, which is shown entire on the large map.

The land in this has been greatly damaged by the finer portions from the dumps, particularly on the right side, close against the hills of which runs a system of high-water channels, carrying down great quantities of sand, and causing the abandonment of a wide belt of formerly fertile bottom to the usual dense thicket of willow and cottonwoods.

The sudden widening in this valley, the sharp turn which it makes in direction, and the narrow gorge by which it is closed below, have made it a natural place of storage and means of protection for the succeeding farms.

Below the site where the dam has been planned, the valley again widens to from 2,000 to 3,000 feet, the hills become lower and lose the lava outcroppings, while the bottom lands for a couple of miles are in the best of order and highly cultivated.

The upland also improves and grows very fair wheat.

From this down to Fisher's (7 miles) the general features of the valley and bordering hills remain unchanged, though it gradually widens to 7,000 and 8,000 feet; but all the cross-sections made showed the bottoms very badly torn and sanded.

This damage seems to increase as we go down, and reach a maximum just above the bridge.

About 3 miles below the foot of the reservoir site the bed of the river, which has before been close to the hills on the south side, crosses to the base of those on the north; then immediately returns to about the center of the valley, and remains there until just above Fisher's, where Mormon Slough diverges from the true Calaveras, and carries its entire low-water discharge. From this on, the two separate widely, the slough trending away to the south and the river to the north.

The hills, which at Fisher's have become low and gently rolling, a mile below separate to the right and left, and the streams come out on the general San Joaquin Plain.

In it the distinction between upland and bottom is quickly lost, and the Calaveras proper from this on to near Stockton is an almost rectangular trench in the plain, 15 feet deep by from 50 to 100 feet in width, generally bordered by a line of large oak timber; while, between it and the slough, we find numerous parallel high-water channels, by which the waters of extreme floods are carried west.

Character of bed.—At the point above referred to, 3 miles below the storage dam, where the river crosses the valley, its bed is still of coarse tailings, with banks, however, of some 15 feet in height.

The owner of the land at this point told me that fifteen years before nothing but sand and mud was to be seen here in the channel, and that each year now the increase in the size of the flood deposit was strikingly apparent. He also showed me a mark, by which I approximately estimated the raising of the bed at 7 feet during the same time.

Between this point and the next cross-section, 4,000 feet farther down, the larger materials disappear, and the bed becomes of very fine gravel and coarse sand; which is still the case for a mile below Fisher's, though the relative amount of sand increases till finally, abreast of Linden, 5 miles farther, it becomes apparently the sole constituent.

Floods and high-water mark.—The flood of 1879–'80 was, according to universal testimony, the most severe since the one of 1861–'62, the height of which it equaled, if not exceeded.

Just below Jenny Lind, lands over which the water had not been for twenty years, were covered to a depth of from 3 to 4 feet.

The following flood-marks were observed. Being all of them drift left the preceding winter, some of them are probably lower than the extreme height.

This is particularly likely for one at the site of the storage dam.

At upper end of survey in cañon, 1 mile above Jenny Lind, high-water, 241.7 feet; water, 230.4 feet; difference, 11.3 feet.

At storage-dam: high-water, 174.2 feet; water, 165 feet; difference, 9.2 feet.

9,000 feet below dam: high-water, 171.7 feet; water, 157.2 feet; difference, 14.5 feet.

15,000 feet below dam: high-water, 165.5 feet; water, 150.8 feet; difference, 14.7 feet.

40,000 feet below dam: high-water, 133.6 feet; water, 124.2 feet; difference, 9.4 feet.

2,700 feet above separation from Mormon Slough: high-water, 128.6 feet; water, 120.4 feet; difference, 8.2 feet.

On Mormon Slough, 7,200 feet below separation: high-water, 119.3 feet; water, 110.7 feet; difference, 8.6.

Slopes.—From Fisher's Bridge up to the site of the dam, the slopes remain practically uniform, and between 5 and 6 feet to the mile.

Above the gorge, at the dam site, they increase to 12 and 13 feet.

Just above the narrowing of the valley, where a second dam is planned, they spring to 36 feet, and above Jenny Lind, near the foot of the dumps, to 41 feet per mile.

Where Mormon Slough separates from the river the latter's bed is higher and its slope for the next mile is steeper, being 7 feet to the mile as against 5.3 feet.

The slope in the 6 miles of cañon above Jenny Lind has been before approximately given as about 50 feet per mile.

Ditches.—Mokelumne and Campo Seco.—This has been described before, being on the Mokelumne. Much the larger portion of its water, after being used in the mines about Mokelumne Hill, at Pine Peak, and Central Hill, drains into Chile Gulch and Jesu Maria Fork.

These unite close to Mokelumne Hill to form the North Fork of the Calaveras, which in turn joins the South Fork, or Santo Domingo Creek, about 3 miles west of San Andreas.

Union Ditch takes water out of North Fork of Stanislaus, in township 15 east, 5 north.

Has no reservoirs.

Flume 6 feet wide, 3 feet deep, three-quarter inch to 1 rod.

Ditch 6 feet wide, 3 feet deep, one-half inch to 1 rod.

Supply lasts nine to ten months in each year, and varies during that time from 2,000 to 2,500 inches.

The bulk of its water has heretofore drained to the Stanislaus, but the new mine at Dogtown will probably take most of it to the Calaveras, while if the arrangements which were being made for its transfer to the company owning the mine at Jenny Lind are perfected practically all its water will drain to the latter stream.

Salt Spring Valley Reservoir and Ditch.—This is the present source of supply for the mines at Jenny Lind.

It is equal to a supply of 550 inches for about six months in each year; sometimes, however, they will run nine, and once had only thirteen days.

The ditch will carry 550 inches; is about 9 miles long, and has, near the mine, one small distributing reservoir, which will hold two days' water.

The supply will probably soon be increased to 1,000 inches throughout the year by the purchase of Union Ditch and the enlargement of the reservoir.

Jenny Lind Ditch takes water out of Calaveras, 9 miles above Jenny Lind.

Its original capacity was 400 inches, which the river supplied to it for from seven to nine months in each year.

Part of its water was carried across the river by a suspension pipe and used at Whisky Hill; the rest on right bank above and for a couple of miles below Jenny Lind.

The ditch, suspension pipe, and dam have now been allowed to go entirely out of repair, and only an insignificant quantity of water is brought down, all of which is used for irrigation. The expense of repairs and the objects for the employment of the water are such that it seems very unlikely that anything will be done to it.

Cook Brothers.—This is a small private ditch, its waters taken out of the North Fork of the Calaveras and used upon a gravel deposit about 4 miles east of Mokelumne Hill.

Its supply may be put at 250 to 300 inches for six months in each year, and all its drainage is to the Calaveras, besides which some of the water in Clark's Ditch, before mentioned, is sometimes brought across the divide to its assistance.

Mining.—To the notices of the chief mines on the Calaveras, submitted in my former report, there is nothing of importance to add, unless perhaps a recapitulation of the names of the several claims, their heads, condition of their dumps, &c. But they are so generally alike in these respects that this seems unnecessary.

The following briefly presents the general facts, as they are likely to be in future.

The Calaveras does now or will probably soon take, for hydraulic mining, the following amounts of water:

1. All the Union Ditch; say 2,500 inches nine months in the year.
2. Practically all of the Mokelumne and Campo Seco Ditch, save 300 inches used in quartz mining, or 700 inches throughout the year; with the improvements soon to be completed.
3. Salt Spring Valley Reservoir and Ditch, or 550 inches six months in the year; or a total of, say, 3,000 inches for the year.

This will be used as follows:

At Jenny Lind	1,000
At Dogtown	1,000
Near Mokelumne Hill	700
Uncertain in small operations at various places	300

The serious present danger comes from the work at Jenny Lind; since their dump is in the main stream, in the head of the valuable part of its valley.

But the easily worked material at Jenny Lind has been exhausted, and there remains now only the hard cemented gravel at North Hill, very small quantities of which are moved per inch; while its very large proportion of coarse bowlders and cobble are stored naturally in the dump.

The mines along Chile Gulch, though presenting a somewhat imposing appearance in the enormous amounts of material already removed, do not seem a formidable source of danger for the future.

Their tailings have been pretty effectually stored in the long stretches of narrow cañon, between them and the dam, which has, I think, been of material assistance in this process.

Moreover, the operations have yearly been becoming more and more restricted in the loss of grade resulting from this storage; many, if not most, of the smaller claims will probably have to be soon abandoned, while the larger can gain a new lease of life only by expensive tunneling.

A great flood in the Calaveras, accompanied, as it would probably be, by the giving way of a very insecure dam, would result in a downward movement of great quantities of this stored material and produce probably very striking changes throughout the valley; of the working at Dogtown the same can be said as regards storage.

It will be long before any but the finer sediment carried in suspension can reach the lower valley.

At the time of my visit the arrangements for bringing in 1,000 inches were nearly finished, but the mine had not been opened.

Only a few insignificant banks, the relics of early workings on a small scale, showed themselves.

The dump was, by a short tunnel, into one of the tributary cañons of Santo Domingo Creek, and seemed to offer facilities for extensive operations.

The gravel appeared fine and clear enough to be easily worked, but as I only saw the end of a spur, where the deposit was thin, I could not judge very well about that.

SURVEY TUOLUMNE.

On October 12, camp was moved to Oakdale. Levels taken from the railroad-bridge over the Stanislaus were transferred to the Tuolumne on the 13th, 14th, and 15th.

The survey on the latter river began at H. Davis's ranch, and was continued to 1¼ miles above La Grange, or 15 miles of its length in all. For some 7 miles from the upper end of the survey both banks of the stream were meandered, where the width rendered it necessary, and throughout the transit and level line was followed by the plane-table.

The results for the 7 miles above referred to have been plotted on the large sheet already submitted, which also includes a special transit and plane-table examination of the mines about Patricksville, on a tributary cañon of the Tuolumne.

The rest of the meander has not been plotted, but the plane-table sheets numbered 1, 2, and 3 give a good idea of the character of the lower part of the stream covered by the examination. Since these last were made from one bank only they are necessarily incomplete as regards the other, especially so where the valley had considerable width.

A special survey was also made of the excavations about La Grange, which forms the basis for a tolerable approximation to the gross amount of material removed from them, presented in my report of last year. On October 26 the work ended, and on the 27th the party returned to Oakdale.

The following is a precise summary:

Total transit and level line, including cross section, 132,426 feet = 25.1 miles.

Connecting line from Oakdale, 74,323 feet = 14.1 miles.

Transit-line, followed by plane-table, 106,516 feet = 20.2 miles.

Number of working days, twelve.

Description Tuolumne.—The cañon of the Tuolumne begins at the town of La Grange, at which place the stream is without alluvial bottom and bordered by steep, rocky hills. A mile and a half above, these close in and become higher and almost vertical, forming a very picturesque cañon, in which the stream flows with a very rapid fall, and bed apparently quite clear of tailings. As far as I was able to follow it up, or for about 10 miles above La Grange, there is no indication of any change having been caused by mining, the only relics of which are a few long-worked-out placers.

Below La Grange the hills for the first time recede, and between them and the river come in stretches of bottom land, high, clear of timber, save a few large oaks, and well cultivated. The bed of the stream is torn out to an excessive width, 1,000 and 1,200 feet in places, and badly choked by enormous masses of cobbles and coarse gravel.

The bordering uplands soon lose their rocky character, but retain considerable heights of from 80 to 100 feet, and rising with very steep slopes from the valley spread off to the north and south in low undulations, which rapidly flatten out as we go down, till at Waterford, 18 miles below La Grange, they are merged in a flat and treeless plain. From this no sign of the river can be seen as one approaches it, till just at the brink of the deep trough through which it flows.

The bottom lands, though generally narrow, remain in good order and well cultivated till about four miles below Waterford. Here a change has taken place in the character of the river's bed, which has become much narrower, lost the broad cobble bars which mark it above, and, though hard enough to be almost everywhere fordable, is chiefly of sand and mud.

The bottom lands below this become very narrow; the entire width of the valley between uplands being in many places not over 400 yards, and are given up to dense thickets of willow and cottonwood, and apparently subject to annual overflow.

Besides their very limited area an additional reason for their practical abandonment is to be found in the excessive steepness toward the river of the upland banks, which, with their height of 50 to 60 feet, makes the valley very difficult of access

The same features are preserved as far down as Modesto. Here the river, though showing large deposits of sand in places, has few signs of having suffered harm; is of normal width and apparently between its original banks, which are high and well grown with large timber.

The uplands are still 50 to 60 feet in height and close together; the bottom lands being a mere strip on one or the other side of the stream. Below Modesto, bottoms remain narrow and practically valueless, the uplands gradually decrease in height, till about Tuolumne City, 10 miles further down, the distinction has disappeared, and the stream for the remaining 4 miles, to its junction with the San Joaquin, flows through the level plain.

Floods and sand damage.—Before the flood of 1861–'62, the Tuolumne, just below La Grange, was a clear stream between high banks grown with large oak timber, and only from 150 to 200 feet apart. In that year the present condition of things was produced almost at a blow, for, though now in each winter tracts of bottom land are washed out here and there, to be replaced by cobble and gravel bars, still the amount of this damage is a mere trifle when compared with the results of that year. The great width which was then given to the water-way has since been a means of protection for the remaining bottoms, as the result of which they have, at any rate, in the upper 20 miles, which includes all the land of much value, not been covered by a flood for twenty years. These lands are now held at from $30 to $40 per acre; upland, $15 to $20.

Many of the farmers seem to think that the condition of things has been gradually improving during that time, but immense accumulation of material now stored in the La Grange and Patricksville dumps is a threatening source of danger, and might in any season combine with an excessive flood to produce the repetition, on perhaps even a larger scale, of the old catastrophe.

From 4 miles below Waterford to Modesto, the bottoms, as before stated, seem lower and subject to overflow, but they are of very small extent and value.

The actual damage thus far done may be summarized, therefore, in the loss caused in the widening of the bed of the stream from 200 to 600 and 800 feet, over some 16 miles of its length.

Filling in of bed.—By a mark on the bank at Dominici's ranch, just below La Grange, I was able to make a good approximate to the raising of the bed at this point since 1850.

An irrigation wheel 33 feet in diameter dipped 2 feet in water and discharged 5 feet above bank, making the latter 26 feet above low-water. The bank is now only 12 feet, indicating a fill of 14 feet. This figure is corroborated by measurements made by me on some large willow trees formerly on the high bank, but now in the bed of the stream. At Roberts' Ferry, about 9 miles below La Grange, the owner showed me marks on his ferry-landing by which he estimated the fill at from 14 to 15 feet, which is probably an exaggeration, since the banks there are now from 15 to 19 feet in height.

Slopes.—The slopes in the lower part covered by the survey were generally about 5 feet to the mile, reaching 13 feet, however, in one steep place a short distance below the La Grange ferry. At Dominici's ranch, and just below the La Grange dumps, the slopes reached 21 and 18 feet per mile. During the preceding season a huge dam of tailings had been formed across the river at the La Grange dump; above this for some distance the water was backed up, without appreciable slope, for nearly 1½ miles, to where the cañon is barred by a high dam.

This is a massive structure of the usual triangular crib-work filled with stone, and were there any considerable quantity of detritus in the stream would undoubtedly keep it in the cañon for years to come. By the grade, length, and height, at discharge of the La Grange ditch, the slope in the 12 miles above the dam can be put at an average of 26 feet to the mile.

High-water marks.—Mr. Dominici, who is a reliable and intelligent man, showed me two high-water marks which he had recorded of the great flood of 1861–'62; one in the gorge just above La Grange Ferry, the other on the lower portion of his ranch. The former was 22.6 and the latter 22 feet above the existing low-water surface, and in their near neighborhood we found drift marks showing the height of the flood of the preceding year as less than 8 feet. Just above the La Grange dumps, a high-water mark of the winter before also gave 8 feet for the rise.

When we remember the fact that the river bed is probably 14 feet higher than it was in 1862, we can form some idea of what might be expected from a flood of the same dimensions happening now.

Ditches.—La Grange.—The most important is the ditch of the La Grange Company. This takes water out of the main Tuolumne, about 12 miles by river, above the mine at Indian Bar. The ditch is 16 miles long, with a grade of 6 feet to the mile, and was built to carry 3,600 inches. It actually does now carry 2,500 inches throughout the year, which is used day and night, and all for hydraulic purposes, in the mines about La Grange and Patricksville. From the character of the cañon the ditch was an extremely expensive one to build, and required a good deal of fluming, which has now about reached its limit of age, and cannot go much longer without expensive and costly repair.

Small ditch at La Grange.—From the dam above La Grange a small ditch carries perhaps 200 inches, which was formerly taken to near La Grange and used for power to pump water from the river, about 60 feet high on the hill, to be afterwards used in gravel-washing. It was never a success, financially, and is now very much choked and out of repair, its water being only used in the irrigation of a few gardens above La Grange.

Golden Rock Ditch.—This takes its water out of South Fork of the Tuolumne, about 12 miles above the upper end of the gravel deposit called by the same name, or about 35 miles east of Garrote. Its capacity is 2,000 inches throughout the year, which is carried along the divide between the Tuolumne and Merced; then separating, part gets definitely into the Tuolumne Basin, about Garrote and Big Oak Flat; the rest into the Merced, by Coulterville.

The total length of ditch is about 60 miles. Of the entire amount carried, 1,500 to 1,600 inches has hitherto been used in the Golden Rock Gravel deposit. The drainage for this has hitherto been to the Merced, but the divide is much steeper, narrowed, and consequently more favorable as regards dump on the opposite side, and the future importance of the mine depends on getting its drainage to the Tuolumne.

The rest of the water has been used, when fall can be found for it, about Coulterville, Garrote, and Big Oak Flat, chiefly as power for mining and tunneling operations, but the demand for it is very slight, and it has mostly gone to waste.

Tuolumne Water Company takes water out of South Fork of Stanislaus, about 14 miles above its junction with North Fork. It soon crosses to the south side of divide, and while on it any required part of its water can be let down by natural channels into Sullivan's Creek, a tributary of Wood's Creek. This is dammed below to form a large reservoir, from which water is again taken out for distribution at various points along the Mother Lode for power, and to the gravel deposit under Table Mountain, in the neighborhood of Shaw's Flat, Sonora, Jamestown, and Montezuma. The drainage of all this is by Wood's and Sullivan's creeks to the Tuolumne, near Jacksonville.

An additional quantity is also taken south from the main ditch, and, after being used for quartz mining at the Soulsby, Confidence, Algerine, and Shawmut mills, also goes into the Tuolumne by Wood's Creek.

After supplying the two ditches above described, the rest of the water goes to the north side of divide, which is much steeper and more abrupt than the south, and is used in quartz mills and small placer washings about Springfield, Columbia, and Gold Spring, with drainage into the Stanislaus.

The total capacity of all the works of the company should be 5,000 inches, and probably is 3,000 inches, the greater part of which, owing to the topography of the divide above referred to, goes to the Tuolumne; but the gravel workings, beside being small in themselves, have their points of discharge in narrow ravines and small creeks and at distances varying from 6 to 14 miles from the main stream.

A branch of the Tuolumne Ditch from their reservoir was formerly carried to Chinese Camp and used there in shallow placer workings, with drainage by Big Creek to the Tuolumne at Don Pedro Bar, 12 miles above La Grange; but it is now out of repair and abandoned.

Mining.—As regards the only two hydraulic mines of any consequence on the Tuolumne, at La Grange and the Golden Rock, there is but little to add to what has been presented in my report of last year. Should the developments of the Golden Rock deposit meet the expectations of its owners, a large discharge of tailings into the main river will result, but it will be at a point high up in the cañon, and could probably for many years be taken care of by maintaining and increasing the height of the existing dam. The workings at La Grange are more threatening, while the topography of the stream below offers at present no facilities for the storage of their detritus, as can best be understood by reference to the sketches of the river already submitted. But the operations of the mine, not at present profitable it is believed, are each year becoming more nearly paralyzed by loss of grade, and a new lease of life can only be secured for it by some great flood, which by cleaning out the main river and some tributary ravines would at the same time cause such changes below as might present the question of storage in an entirely new and more favorable light.

The only considerable remaining deposit of gravel in the basin is that existing under the lava of Table Mountain and in some small outlying placer deposits and low spurs from the main ridge. The extreme end of the most important of the latter can be seen in the low banks just back of Chinese Camp, which have been abandoned, and further traced through Jamestown and Montezuma, where it is still being worked in a small way, to its junction with the main body of the mountain.

About Shaw's Flat, Springfield, and Columbia the deposits are shoal, flat, and practically exhausted. They lie upon the belt of limestone which is parallel and to the east of the Mother Lode and are worked by hoisting the material out in buckets and throwing it into tail sluices. The gravel under Table Mountain is somewhat extensively worked by shafts and drifts, but the results discharged, as they are far from the main stream, are practically insignificant. Along Wood's Creek and at places on the main river from Indian Bar to Jacksonville the Chinese are still working in the tailings and old bars, at times with considerable success. It was reported when I was in Sonora that one such claim near Jacksonville had lately yielded $35,000 in three weeks.

Considerable quartz mining is always going on along the belt of the Mother Lode, whose outcrop is very strikingly marked across the country between the Tuolumne and the Stanislaus. It strikes across the Tuolumne near Moccasin Creek, and between Jamestown and Montezuma can be seen standing up across the country like a huge white wall, and then disappearing under the lava cap of Table Mountain.

The results in gross of the operations of all these quartz mills were given in my report as nearly as they could be obtained at the time of my visit. I got the names and situations of all the mills which were then actually at work, but they are so frequently suspending and resuming that these results can only be regarded as a tolerable average.

The following connections were made during the survey with the work of the State engineer:

On line from Oakdale to the Tuolumne, at Bell's ranch, Dry Creek, gauge elevation of zero, 132.38.

On Tuolumne River bench-mark, State engineer department, 10 = 193.96.

Bench-mark, State engineer department, 11 = 168.29.

SURVEY STANISLAUS.

The survey began October 28, levels being taken from a railroad bench-mark on the south end of the south space of the Howe truss bridge across the Stanislaus at Oakdale.

The transit and level meander, accompanied by plane-table sketches, was carried down the right bank for over 12,000 feet, but the valley here became so wide that the plane table could no longer be used with advantage in the limited time at our disposal, and it was given up, though the meander was continued to Myer's ranch, about 6 miles below the bridge.

The line, with plane-table sketches, was then carried up the valley to about three-fourths of a mile above Knight's Ferry, which is itself, by river, 12.7 miles above Oakdale.

Here both banks were meandered for between 3 and 4 miles.

The transit notes have not been plotted, and none of the plane-table sheets have been transferred. Six of these are transmitted in the original, covering in all 15.6 miles, by the river, below Knight's Ferry.

The following is a precise summary:

Total transit and level lines, 12,988 feet = 2.46 miles.

Followed by plane-table, 97,951 feet = 18.6 miles.

Number of working days, nine.

The following connections were also made with the State engineer department surveys:

Zero, State engineer department gauge, at Oakdale Bridge. (102.17.)

Zero, State engineer department gauge, above dam, at Knight's Ferry. (181.62.) Ref.

State engineer department bench-mark, 32 Lancaster's ranch. (193.29.) Ref.

Description Stanislaus.—At Knight's Ferry the Stanislaus comes out of a narrow cañon, whose sides at first steep lava hills, become within 2 or 3 miles above almost vertical cliffs of 500 to 600 feet in height.

Between these the river flows in a bed entirely clear of tailings, but filled with large bowlders and having evidently a very rapid fall.

The only other view I had of the cañon was as Parrott's Ferry, some 30 miles above. Here the river is a clear and rapid mountain stream, between steep walls from 1,200 to 2,000 feet in height, and shows no sign of having been damaged by hydraulic mining.

Just above Knight's Ferry the hills flatten and widen out, leaving between them and the river high banks of auriferous gravel; but they come close together again, about 1¼ miles below, to form a very narrow gorge, with nearly vertical walls, remarkable as the last evidence on the surface of the great lava flow which forms the top of Table Mountain and such a striking topographical feature in the country between Knight's Ferry and Sonora.

From this point down, the country rock is a coarse friable sandstone, which, a mile below this lava gorge, comes close to the river in steep cliffs 300 feet in height, crops out of the hills at intervals further on and forms the bed of the deposits of gold-bearing gravel which, for some 5 miles below Knight's Ferry, lie between the high lands and the stream.

The disintegrated elements of this stone are found also in the terraces, or second benches, which form a characteristic feature on the Stanislaus.

These stand just back of and from 40 to 60 feet higher than present alluvial bottom, to which they are joined by a very sharp slope.

On one of these benches is the town of Oakdale.

The river bed, for 8 miles below Knight's Ferry, is of cobble and coarse gravel, with widths varying from 400 to 800 feet; the high lands on either side are close to the bank, and though here and there are narrow strips with less than 20 feet elevation above low-water there is no properly so called bottom under cultivation.

Below this, again, to the Oakdale bridge, 5 miles farther, we find some limited areas of alluvial land, chiefly on the left bank, but they are high, clear, well cultivated in wheat, and, so far as I could learn, have not been covered in floods since 1861-'62.

In this latter portion the general character of the material of the bed remains about the same, though showing here and there deposits of coarse sand; and its general width narrows to about 400 feet save in one place, 2 miles above the Oakdale bridge, where a cobble island, 800 to 1,000 feet wide by three-fourths of a mile in length, torn from the original bottom, divides the stream at low-water into two channels.

Below the Oakdale bridge the uplands have become flat terraces, from 60 to 80 feet above low-water, which widen out to inclose extensive tracts of high, well-cultivated bottoms, not subject to overflow, and from 3,000 feet to a mile in width.

The broad cobble bars disappear in the next 2 miles, and the bed becomes of coarse sand and fine gravel, with a general width of some 400 feet, though near the lower end of this portion there is another break, where, for about one-half a mile, the banks are 1,200 feet apart and between them are low, sandy islands grown with willow. Eighteen thousand feet below the bridge we find for the first time the stream only 200 feet wide, in sand alone, and between what appear to be the original banks, which are high, firm, and thickly grown.

From this on for 2 miles farther the general conditions remain the same; high, wide, and well-cultivated bottom lands, not overflowed since 1862, are on both sides of the stream, which is generally 200 to 300 feet broad, though here and there for short distances the banks have been slightly torn out and replaced by beds of sand.

Below this the valley undergoes again a complete change in form, analogous to that before described for the Tuolumne below Waterford. It enters a sort of secondary cañon, the upland banks of which, quite flat on top and retaining heights of 60 feet, come within 600 to 1,200 feet of each other, while the very narrow strips of bottom between them are rarely on both sides of the stream, and, being lower than those above, are subject to annual overflow and generally abandoned to dense thickets of willow and cottonwood.

At Buneyville Ferry, 7 miles below Oakdale, the same description applies, though the upland banks are there lower (perhaps 40 feet above the stream), and it also is true for practically all the remainder of the river, till quite near the San Joaquin, where all distinctions of level have become merged in the general plain.

Land damage.—From the above description it will have been seen that the land damage by floods along the Stanislaus has been insignificant. The only bottom land, of any importance, is to be found in the 5 miles below Oakdale bridge and a few fields in the 4 miles above.

These were flooded in 1862, but very probably improved thereby; the main damage being the small areas destroyed by the widening of the stream, which, in turn, has saved most of the remainder from overflow since.

All the people along the banks unite in saying that the changes during the past eight or ten years have been very small and gradual.

Fillings.—I am of the opinion that below Knight's Ferry the bed of the stream has not been materially raised; to which conclusion I have arrived by the testimony of many people, the appearance of the banks, and the absence of the usual signs of such raising in buried trunks of trees.

Though the river is barred at Knight's Ferry by a solid dam, the cañon above shows no more material resembling tailings than might be expected in any mountain stream of its slope and discharge; from which it may be inferred that we are to seek the cause of such changes as it has undergone in the mining below the ferry.

Flood marks.—A State engineer department gauge had been kept during 1879-'80 above the Knight's Ferry bridge by the toll collector. The extreme flood heights for these years respectively were 5.1 feet and 5.8 feet above the low-water surface; as found at the time of our survey, or 0.6 foot below zero of the gauge. Unfortunately no reliable flood-marks of those years could be found below the bridge.

The difference in level between the pool above and stream below at low-water was 14 feet; hence, 20 feet would be the maximum even supposing the flood to pour over the dam with a perfectly level surface.

In contrast to this we had a reliable mark, recorded with the date January 11, 1862, on the wall of the brewery at Knight's Ferry; which was 34 feet above the water surface of the river opposite.

Hence, the flood of 1862 must have exceeded by 14 feet, at least, the considerable one in April, 1880.

Slopes.—The slopes on the Stanislaus are a good indication of its being in better order; since they are more gentle and uniform even than those of the larger Tuolumne.

From the lower end of the survey to Lancaster's ranch, 6 miles below Knight's Ferry, they vary from 3 to 5 feet per mile; beyond this, while the average does not materially increase to the dam, we find some sharper pitches of 9 feet and 12 feet per mile.

Ditches.—Union. This ditch has been before described in the report on the Calaveras. It has heretofore carried most of its water for use in quartz mills and arastras about Murphy's and Angel's, and small placer and gravel washings about Murphy's, Vallecito, and Douglas Flat; with drainage through Angel's and Coyote creeks to the Stanislaus.

Tuolumne Water Company.—This ditch has been also described in the report on the Tuolumne. Considerably less than half its water drains into the Stanislaus after being used in irrigation, shallow gravel-washing, and small placers near Springfield, Columbia, and Gold Spring.

San Joaquin.—Six miles above Knight's Ferry, at Burns' Ferry, a dam takes water out of the Stanislaus for the San Joaquin ditch, which comes down the right bank now to nearly 5 miles below Knight's Ferry; though it originally went some short distance farther.

It was built to carry 400 inches, and is now equal to 160 inches; which are used in summer for irrigation and in winter to run two small hydraulic claims, to be mentioned hereafter.

Table Mountain Ditch.—About 2 miles above Burns' Ferry, another dam took out water for the Table Mountain Ditch, which came down left bank for some distance below Knight's Ferry.

The dam was destroyed in the winter of 1879–'80, and the ditch has been out of repair and unused for ten years.

Irrigating Ditch.—A scheme is on foot to replace this Table Mountain dam, or build one near it, to take out water for the irrigation of the lands about Farmington, between the Stanislaus and Calaveras.

This is to be a large and expensive affair; one part of the project being a tunnel 1,600 feet long, 800 feet of which have already been pierced.

Work on it has now been suspended, and its completion is doubtful.

Mining.—Stanislaus.—The most important mining on the Stanislaus as regards the quantity of water used, the results and probable continuance, are the claims about Columbia, drawing water from the Tuolumne Company, and those about Vallecito and Douglas Flat, supplied by the Union Ditch.

But these are all worked in a very small way, generally in the washing of excavated material, while their discharge points are well back from the main river, in tributary ravines and creeks, which empty into it high up in the cañon, which seems now quite clear of tailings and is closed at Knight's Ferry by a dam.

Below Knight's Ferry both banks of the stream are honeycombed by old mining operations for between 2 and 3 miles; while beyond, for 3 miles farther, worked-out claims are seen here and there; but the only ones now actually going on are two on the right bank, marked on the plane-table sheets 2 and 4 miles below Knight's Ferry, respectively.

The lower of these uses 60 inches of water from about the 1st September to the middle of May.

Bank of gravel 15 feet high above coarse sandstone, with 10 feet of sand on top of gravel.

Canvas hose, 25 feet head and 3 inch nozzle. It has been owned and worked by one person for many years.

The upper one, also owned and worked with similar primitive appliances by one person, uses 100 inches for the same period.

This bank is higher (say 60 feet), the top 10 feet, being a fine loam which carries the largest and heaviest gold. In fact, it is found in the grass-roots.

Both these dump, of course, directly into the main river, with very light grades, which are each year destroyed only to be restored by the winter flood.

There is undoubtedly much gravel below Knight's Ferry, which would pay in a small way for working; but beside the difficulty inseparable from its situation of lack of grade, there is another in the extremely precipitous nature of the lower cañon, making the construction and maintenance of a ditch very expensive.

That these are practically prohibitive is shown in the abandonment of one ditch and the decay of another, and the total cessation of even the very small operations which now directly affect the river may soon be expected.

It is also significant that while on all the other southern streams Chinamen are everywhere met with on the old bars and tailing heaps, on the Stanislaus, when I saw it, there was not one, though I believe that in winter a few usually do work at Burns' Ferry.

The preceding remarks seem to justify the conclusion stated in my report of last year, that protection on the Stanislaus from the results of hydraulic mining is not at present a question requiring consideration.

MERCED.

A personal examination which I made of the Merced, covering it for 6 or 8 miles below the point where it comes out of its cañon at Merced Falls, convinced me that no instrumental examination of it was called for by the object of the surveys.

In its general features the stream is strikingly like the Tuolumne and Stanislaus, and unlike the Cosumnes and Calaveras.

Between Merced Falls and Snelling the bottom land gradually increases to one-half or three-fourths of a mile in width, is high, well cultivated, and descended to from a high table-land by a sharp slope, which completely hides the river till its upper crest is reached.

The water-way was torn out in 1862 to excessive width, and at Snelling is, in several channels of coarse cobble, perhaps 400 yards across.

The water is perfectly clear, and it is also very noticeable to one familiar with this particular zone on the more northern rivers that there is here a total lack of trace of early mining of any kind.

Below Snelling the bottoms get wider (from 1 to 2 miles) for 8 miles farther, and are high and in good order, where we again met with a peculiarity which has been commented on for the Tuolumne and Stanislaus.

The bluffs on either hand come close together; the bottoms either nearly disappear or are reduced to low, overflowed, and abandoned strip on one or the other bank. This condition continues till the bluffs disappear in the plain close to the San Joaquin.

No mining operations now affect the Merced save those of a few quartz mills and the Golden Rock Hydraulic Company, whose drainage point has hitherto been far back from the river and is soon to be transferred to the Tuolumne.

Very respectfully, your obedient servant,

A. H. PAYSON,
First Lieutenant, Engineers.

Col. G. H. MENDELL,
Corps of Engineers, U. S. A.

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2. REPORT OF MR. MARSDEN MANSON, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
San Francisco, Cal., January 5, 1882.

SIR: During the past season it has been my duty to examine, under your direction, the condition of Feather, Yuba, Bear, and American rivers, the available storage for mining detritus upon each, and the general condition of the hydraulic mines upon and in the drainage area of these rivers. The following report is respectfully submitted.

In the course of these examinations it became necessary to make special examinations of certain localities, the results of which have been submitted to you from time to time as they proceeded or were completed. Such of these as bear upon the general subject will be referred to in the treatment of each river.

The order pursued will be from Feather the most northerly to American the most southerly of the streams examined.

FEATHER RIVER.

A reconnaissance was made of Feather River and its tributaries during the months of June and July last, and a survey of that portion of the river immediately below the foothills. This river has the largest single mountain drainage area of the State, comprising about 3,400 square miles on the western slope of the Sierra Nevada, and embracing the whole of Plumas and portions of Butte, Shasta, Lassen, and Sierra counties. The elevation of this basin above tide water varies from 150 to 10,000 or more feet, most of it is timbered, some very finely, but the greater portion is only covered with a light growth of pine, fir and oak interspersed with the usual California mountain undergrowth.

Well up in the mountains occur broad valleys or meadows, which are frequently swampy.

These are highly valuable as pasture lands, and occur above the limits of hydraulic mining in all instances but one, and at elevations of from 3,400 to 5,000 or more feet.

The surface rocks are principally slate, granite, and lava; the decomposition of which determines the general nature of the soil.

The natural or unavoidable wash from the basin of Feather River is great, and the wholesale stripping of the fine timber districts and the unrestricted pasturage of large herds of stock renders this wash greater year by year.

The five principal arms of the river suggest a corresponding subdivision in treating the river.

These five arms or forks are known as the North, Middle, and South forks, and the East and West branches of the North Fork. Their relative positions and extent are best ascertained by an examination of the maps of Plumas and Butte counties, which are herewith submitted, or of a general map of the State. When examined during June and July last, these streams were discharging about the following quantities of water:

West Branch	150 to 200	cubic feet per second, tinged reddish.
North Fork	1,000 to 1,200	cubic feet per second, muddy red.
Middle Fork	600 to 700	cubic feet per second, clear.
South Fork	100 to 125	cubic feet per second, tinged reddish.
Total	1,850 to 2,225	cubic feet per second.

The river was by no means at its extreme low-water discharge, and perhaps decreases 25 or 30 per cent.

Its mean winter discharge varies between 5,000 and 10,000, and flood discharge from 50,000 to 75,000 cubic feet per second. Appended is a table of grades deduced from barometric observations and the United States land maps and other data. This table shows approximately the grades existing in the various forks.

North Fork and Main Stream.

From—	To—	Distance in miles.	Fall per mile, in feet.	Rise of floods above low-water.	Remarks.
Bidwell's Bridge	Carriboo	15	115	8	Two falls between.
Carriboo	Mouth East Branch	6	65	10	
East Branch	Chip's Creek	3	63	30	
Chip's Creek	Buch's Creek	8.5	52	25 to 30	
Buck's Creek	Upper end Big Bend	19	46	25 to 30	
Upper end Big Bend	Mouth West Branch	12	36	25 to 30	
West Branch	Middle Fork	9	50	25 to 30	
Middle Fork	Oroville	7	14	40	
Oroville	Burt's Ferry	12.8	4.26	40 to 22	Report State engineer 1880, part ii, pp. 32-35.
Burt's Ferry	Yuba River	24.2	1.46	22 to 25	
Yuba River	Nicolaus	19.6	1.21	....	
Nicolaus	Sacramento River	10.4	0.92	....	

West Branch.

From—	To—	Distance in miles.	Fall per mile, in feet.	Rise of floods above low-water.	Remarks.
Nelson Bar	Yankee Hill Road	3	35	20 to 30	
Yankee Hill Road	Mouth	2½	36		

Middle Fork.

From—	To—	Distance in miles.	Fall per mile, in feet.	Rise of floods above low-water.	Remarks.
Nelson's Point	South Fork	45	84	25 to 30	
South Fork	Bidwell's Bar	1¾	34		
Bidwell's Bar	Mouth	2	50		

South Fork.

From—	To—	Distance in miles.	Fall per mile, in feet.	Rise of floods above low-water.	Remarks.
Stringtown	Mouth	3	22	15	

The general condition of each branch and the mining upon and in its basin is as follows:

WEST BRANCH.

The cañon of this stream was examined from Nelson's Bar to its mouth, a distance of 5½ to 6 miles, and at a point opposite the Morris Mines, 30 miles above Nelson's Bar. The general features are: Grade about 35 feet per mile, average width at bottom 90 feet, sides slope at angles of about 30 to 35 degrees for the first 200 feet, and then fall into the lighter slopes of rounded mountains rising 1,200 feet above the river.

The bed of the stream is composed of clean slate and other rock *in situ*, large bowlders of granite, lava, and syenite, with water-worn stone of less dimension, and a few scattered bars of gravel in protected places.

The water during summer is nearly clear and perfectly potable; floods leave no deposits that have an unnatural appearance. The whole cañon is clean of *débris*, and the stream presents the appearance of having carried none of moment.

No desirable storage areas occur. The most extensive is at Nelson's Bar, where the river widens to 150 to 200 feet, with sides of from 25 to 27 degrees, and a length in this wider reach of about 200 yards. Fortunately no storage is as yet needed.

Mining on the West Branch.—There are no hydraulic mining operations of moment in the basin of the West Branch.

Bars and very limited deposits of gravel have been mined in the past at several localities, but have been practically worked out and abandoned.

At Red Hill, near Dogtown, preparations are being made to introduce a supply of water of 1,000 miners' inches to work a deposit of gravel reported to be some 20 acres in area, and from 5 to 50 feet deep. If this project is carried out the material will be discharged into the West Branch at a point where it would be difficult and costly to store, and where, if not stored, would either cost very heavily to store below or aid in doing much damage.

The West Branch derives its principal importance as a factor in mining operations from its water supply. It, with Butte Creek, furnishes the Cherokee, Miocene, Powers, and Hendricks ditches.

NORTH FORK.

This is the main arm of the river, and has a drainage area greater than the combined drainage areas of the other forks. Its cañon was examined from Bidwell's Bridge (at the lower end of Big Meadows) to Oroville, a distance of about 80 miles; it is rarely less than one-fourth mile deep, and is generally from one-half to three-fourths mile deep; the bottom width seldom exceeds 200 feet, and is generally about 100; the sides slope at angles of from 25 to 75 degrees. During low and mean stages the water of the North Fork above Swiss Ravine is beautifully clear and cold; below Swiss Ravine deep red, and carrying some sand in suspension. Swiss Ravine is at the head of the hydraulic mining yet developed, and brings in the detritus from Dutch Hill.

At many points occur bars or old deposits of bowlders and cobbles in benches 20 or 30 feet above the bed, and a few hundred feet long; these bars have been or are being mined, together with many parts of the bed of the stream.

The natural wash entering this fork is very large; small streams upon which there was neither mining nor farming show evidences of having carried quantities of granitic sand. The sides of the mountains when of granite are often very easily disintegrated, and as this disintegration proceeds the loosened material rolls and slides down even during dry weather. The decomposed lava, covering large areas, forms generally a very light soil which is also very easily washed down, particularly when the protecting timber and vegetation are swept off. The indications on the small streams present themselves all the way down the main stream, and the flood deposits on the lands below Hamilton Ferry, although accredited to a mining origin, are noticeably mixed with this sand.

The principal tributary of the North Fork is the East Branch, which is formed by Indian and Spanish creeks. The other tributaries of the North Fork are small, having a low-water discharge rarely exceeding 3,000 miners' inches, or from 75 to 80 cubic feet per second.

Hydraulic and other mining on the North Fork.—The limits of hydraulic mining on the North Fork, are from Dutch Hill to Big Bar, a distance of about 36 miles. Detritus enters from the following streams in order and about in the quantities given in the subjoined table:

Streams.	Mines.	Quantity per year.	Remarks.
		Cubic yards	
Swiss Ravine	Dutch Hill	500, 000	Fine material.
East Branch	Quincy Group. Brooks Halstead	323, 500	Maximum quantity, needing storage.
Yellow Creek	Yellow Creek claim.	(1, 000, 000)	Estimated capacity not yet developed.
Chipps Creek	Lotts	140, 000	
Flea Valley	Big Bar	15, 000	
	Morris		Does not reach Feather River; stored in Morris Lake.
		978, 500	
		1, 978, 500	Including the estimate for Yellow Creek.

Of these the Quincy Group, heretofore described, include by far the richest and largest mines. Eighty per cent. of the material they move finds natural storage in and above the American Valley. The annexed table gives an idea of these mines.

Quincy Group and Mines on the East Branch.

No.	Name.	Condition.	Water used yearly, miners' inches.	Material discharged.	
				Total yearly.	Estimated amount reaching the North Fork.
	Quincy Group:				
1	Falls Hill	Not worked			
2	Mountain House	do			
3	Bean Hill	do			
4	Cadwalader Hill	do			
5	Gopher Hill		100, 000	435, 600	87, 120
6	Badger Hill	Not worked			
7	Hungarian Hill		57, 200	289, 000	57, 800
8	East Fork Mining Co		12, 000	48, 000	48, 000
9	Hardsock	Not worked.			
10	Halstead		16, 000	48, 000	48, 000
11	Brooks		38, 400	110, 000	[illegible], 000
12	Keeps		20, 000 to 30, 000	27, 000	27, 000
13	Laguire		1, 400	5, 600	5, 600
	Total			903, 200	323, 520

There are also as seen from the water returns numbers of drift and quartz mines at Savicool, Sunnyside, Jaw Bone Flat, Cariboo, around American and Indian valleys, and other points. The method of mining these only discharges the lightest material, the coarse being stopped in the mine or not discharged into the sluices in the case of the drift mines, and only the fine material from the mills in the case of quartz mines. This débris is of so fine a nature and so small in amount as to need no consideration so far as its effects upon navigable rivers are concerned. It is doubtful whether its effects could be observed, at the lower end of the cañon during low-water, and they bear so small a proportion to the natural wash as to require no attention as yet.

In addition, there are also river-bed claims from Savicool to Hamilton Ferry; many of these are leased to companies of Chinese miners; there is scarcely a reach of 5 miles without one or more of these companies. Around Big Bend 12 miles of river bed are covered by one patent. The obstacles these would make to utilizing the bed of the river for storage are almost beyond reasonable estimate.

Storage on the North Fork and its tributaries.—As previously reported, the only rich mines worked by the hydraulic process in the basin of the North Fork are those of the Quincy Group. The impression derived of the others was not flattering. The Quincy Group has a natural storage for its heavy material in American Valley, apparently 80 per cent. of the material having lodged in the cañon of Spanish Creek and at the head of American Valley. The owners of these mines have acquired by purchase the right to dump material into American Valley. The grade of Spanish Creek above is about 35 feet per mile, and through the valley 12 feet per mile. Well-informed residents assert that no coarse material passes through the valley, and the appearance of the cañon below certainly bears testimony to the correctness of their statements. There is, then, no need of additional mountain storage for the Quincy Group, for all the material which could readily be stored in a mountain reservoir is naturally provided for in American Valley, and the mining companies have paid for the right to use such storage.

The mines needing storage are the Brooks and Halstead, now worked; the Hardsock and East Fork mines, should they resume work, and other little mines only partly using the hydraulic process, together with any mines which may be developed in the future. Under this last head may be mentioned a scheme which, if developed, will necessitate a need for a very large storage. This is a project by a Boston company to drive a tunnel from a point in American Valley to Spanish Creek, near Butterfly Bridge, and to hydraulic out portions of American Valley. The existence of rich drift mines around the edge of the valley, and the fact that most of the soil is alluvial wash from slate, carrying gold-bearing quartz veins, warrants the belief that there is gold in paying quantities on or near the bed rock. The company has bought large tracts of land and the water rights of Spanish Creek over the section affected, and is able to carry out the project. The amount of material which can thus be handled is greater than all now handled in the basin of the North Fork, and if carried out will discharge into Spanish Creek at a point below which storage cannot be provided except at great cost, and where, unless stored by very expensive structures, it will be swept out of the cañon of Feather River, causing an increase in the already great injury wrought upon that stream.

There is a point about half way between Rich Bar and Twelve Mile Bar on the East Branch where the bottom of the cañon is about 100 feet wide, sides sloping at angles of 35 and 40 degrees. Material of good quality for a stone dam is abundant on the sides. The grade of the stream above is about 35 feet per mile, average width 150 feet, sides slope at angles of 30 degrees. The grade of stored material would probably be about 12 feet per mile. It is not considered necessary to estimate upon a dam at this point at present, for, in the first place, mines now needing storage are not in a prosperous condition, and probably not worth the dam, and it is by no means certain that the river bed, if needed, may not be found very valuable in places; nearly every foot of it has been the scene of mining operations; and in the scond place it will be at least several years before the scheme mentioned can be fully developed, by which time the State and local laws, and probably the United States laws, may have placed the matter of storage in a different form from that which it now presents.

As for the mines upon Swiss Ravine, Chipps Creek, Big Bar, and the recently developed Yellow Creek claim, they are so small and discharge into a river of such great flood capacity, that it is very questionable whether their combined gross products would compass the cost of a dam, much less purchase the claims in the bed of the river which it would be necessary to condemn, were a dam constructed for storage purposes.

There is, however, a site at the mouth of Grizzly Ceeek; the right bank slopes at an angle of about 35 degrees, the left is a granite bluff having a slope of 75 degrees and extending some 300 feet above the river; the width of river bed is about 130 feet. The cañon has a steep grade above, some 46 feet to the mile; is perfectly clean; with its narrow water-way, rarely over 200 feet, sides of 35 degrees, and a very large flood discharge, the storage space above would be very limited. The same may be said of any other point of the cañon.

THE MIDDLE AND SOUTH FORKS.

These streams present the same general characteristics regarding water-shed and features as are found upon the North Fork. Their grades and discharges have been previously given. They were examined for several miles above their junction and at frequent points near their headwaters.

Hydraulic mining operations upon them are very limited, and their cañons when compared with Yuba, Bear, and American rivers are perfectly clean; they carry no débris of moment. The Middle Fork at all points was clear and its sides free of débris. A few limited operations are reported to be carried on at Nelson Point during the wet months, but at the time of examination these places were deserted. At the Saw Pit Claim on Onion Valley Creek there is a limited deposit of fine gravel worked during past years at limited times and to a very slight extent; the mine was idle the greater portion of 1881 and the prospects such as to justify one in making no estimate for its future operations. There are a few drift and quartz mines in the same basin, but few were being worked last summer and many had been idle for years. It was not considered necessary at present to examine the storage upon Onion Valley Creek. In Granite Basin there were reported quartz and drift mines of flattering prospects, but as no hydraulic mining was reported it was not considered necessary to visit the district.

At Moresville, on the South Fork, a Boston company has purchased and is preparing to introduce a large supply of water to work a mine which has not been very actively worked since 1868. The work will probably be finished in 1882; and from what could be learned the company will be prepared to discharge detritus into the South Fork at the rate of 500,000 to 750,000 cubic yards per year.

There is no desirable storage for this material in the cañon of the South Fork; the grade is too steep and the cañon too narrow; no material has lodged beyond the slight grading up of the interstices between bowlders; its waters were only slightly muddy. Past operations at Bidwell's Bar and Stringtown were extensive, but these points are now desolate. The river bed near each place was the receptacle for large quantities of bowlders and cobbles which have found permanent resting-places; and finer material has gone to swell the deposits below the mouth of the cañon.

FEATHER RIVER AT AND BELOW OROVILLE.

There is submitted herewith a map of Feather River from a point 2 miles above Oroville to Burt's Ferry, also cross sections of the river at the points indicated on the map. This map was made from the United States land surveys; the sections were made in September, 1881. From the information given by those most familiar with the localities, it has been ascertained that this reach of Feather River has filled from 5 to 35 feet, probably equivalent to 10 or 12 feet over the whole span covered by the low-water channel of the river. Just opposite Orovile bars of several acres in extent were raised during the flood of February, 1881, by the material swept from the dumps immediately above, from 3 to 8 feet. The flood of last February was higher by 1.3 feet at Oroville than the great flood of 1862, although from 2 to 6 feet lower at points above. A large and valuable portion of the town of Oroville is beneath the flood plane. This area is shown on the map of that town herewith submitted. Should structures be erected below for storage purposes they will injure this property and possibly more. The estimated value of that now below the flood plane is $150,000.

Material discharged into Feather River at Oroville.—Owing to the condition of the injunction suits in progress it was frequently difficult to get definite information from many mine-owners regarding the quantity of material discharged; and as the mines were not running at the time of the examination, it was not practicable to get definite figures. Still, sufficient information is on hand to give a fair approximation of the amount of material which can be moved in the Oroville group of mines.

The water supply for this group is obtained from four ditches namely, Powers, Hewit, or Feather River, and Ophir, Hendricks, and Miocene, each of which was examined and a fair idea of its capacity obtained. The duty of water in the Feather River mines as given by the State engineer from careful measurements at Oroville, and from other data, is 3½ cubic yards per twenty-four-hour miner's inch. (Report of State engineer, Part III, page 24.)

The ditches above mentioned have the following history and capacity:

Table showing daily capacity of Oroville Ditches.

No.	Name.	When built.	Source of supply.	Capacity in twenty-four-hour miners' inches, according to season.
1	Powers	1853	Little Butte Creek	500 to 800.
2	Hewit	1856	South Fork	1,200 to 1,300.
3	Hendricks	1871	West Fork	Upper ditch, 1,200; lower ditch, 600 to 800.
4	Miocene	1878 to 1880	do	3,000 to 3,500.
	Total			5,300 to 6,400.

Of these the Powers Ditch furnishes the water supply of Oroville, and possibly some little irrigation water en route. The Hewit furnishes the Oroville water-mill with 100 inches per day, and probably 500 acres in fruit, vineyards, and gardens with irrigation water, and also the Lava Beds with the water used by the Chinese in their mining operations. The waste products from this Chinese mining do not reach Feather River, as most of the work is done with rockers and sluice boxes, and not discharged where flood waters of tributaries can transport it. The operations of the Oroville mines were restricted during 1881 by an injunction obtained by Yuba and Sutter counties, restraining the Miocene mine from discharging its waste products into Feather River. This injunction was against one mine only, the largest, but the other mines stopped work, pending the result of the legal proceedings. The available water supply, and the duty given by the State engineer, from the basis form the most accurate estimate of the amount of material which may be moved by these mines.

The Miocene, using its least supply of 3,000 inches per day for 300 days per year (or 900,000 inches per season), can discharge 3,150,000 cubic yards per year. It is reasonable to accept the figure before given of 3½ cubic yards, as this mine is well fitted, has every appliance for mining rapidly; its sluices are on a grade of 5 inches per rod, or five one-hundred-and-ninety-eighths, and its supply of water large and unfailing. The other mines, namely, the Oroville Mining Company, Hendricks, and Hewit, used in 1880, as per returns of the assessor of Butte County, 248,000 inches. This would move 968,000 cubic yards per season, or a total of 4,118,000 cubic yards. The Miocene is just prepared to commence work; the others have been working from ten to twenty-five years.

Storage for the Oroville Group.—A study of the map and cross-sections submitted, or an examination of the ground, reveals the fact that there is no storage for this amount of material.

The river bed is owned and mined at several points with at least as flattering prospects as any mine needing storage. To allow the discharge of material from these large operations to continue uninterrupted will surely involve the raising of the river bed to such an extent as to practically destroy its channel and to force the river across a very valuable and fertile country, the North Butte Basin, the value of whose products is manifold the value of the mines, to say nothing of the injuries arising from the almost certain obliteration of the navigable portion of Feather River, from Marysville to the Sacramento River, with its accompanying disasters to both town and county property.

The restriction of mines from discharging waste products into rivers, when these products cannot be stored within a reasonable figure, may bear heavily upon some properties and injure some speculations, but this restriction will not prove so disastrous as many are led to believe, particularly in the case of valuable rather than speculative mining. The hydraulic elevator furnishes the means to store waste material in portions of a mine already worked out, or of raising it so as to command sufficient grade to store elsewhere. Several forms of this appliance were observed at work, but the device is as yet not in its best and most effective form, and in one or two observed instances much power was lost by poor construction. It is successfully at work at Ohio Flat, on Dog Creek, and at Hoosin Bar, on the Middle Fork of the American. At the former place 390 inches of water, under a pressure of 375 feet, raised 400 inches of water and 3 cubic yards of detritus per inch through a vertical space of 35 feet. At the latter place 400 inches of water pumped 150 inches and raised 2,000 tons of gravel 48 feet per twenty-four hours. It was also observed at Oroville and Bidwell's Bar, but was not in use. The elevator consists of an open or closed inclined sluice, into the lower end of which water and other material is introduced and forced up the sluice by the discharge from a nozzle of a volume of water under heavy pressure, and having a velocity of 125 or 150 feet per second.

FEATHER RIVER FROM BURT'S FERRY TO MARYSVILLE.

The river was examined from Oroville to Marysville, in addition to the survey made near Oroville, and previously referred to. At the Oroville Bridge the flood section was 16,000 square feet during the flood of February last; at Hamilton Ferry the flood section of the channel proper was 7,100 square feet, although there were flooded areas and sloughs increasing this. Lower down the channel-way decreases in places, until it reaches its minimum near Honcut Creek. Here it is so narrow and choked with snags and brush that a small boat could hardly get through. Below, the water-way is tolerably uniform, and about the same as shown by the sections taken by the State engineer department in 1879. No comparison was made, but the general features as presented to the eye have not changed.

The depth of water during low stages is about 2 feet; in places depths of 10 and 11 feet were observed. The banks are from 10 to 20 feet high, and although generally firm have been attacked and washed badly in many localities, owing to the filling of the river bed. The bottom is of cobble and gravel near the Oroville mines, and as far down as Hamilton Ferry; there gravel principally, as far as Honcut Creek; at and below Honcut creek to within 6 or 7 miles of Marysville, coarse sand; and in the reach of slack water above the mouth of Yuba River, fine sediment, overlaying fine gravel and sand.

Very large volumes of flood water now escape in the neighborhood of Hamilton and Burt's ferries, and flow into the Butte Basin, leaving Feather River entirely.

These floods formerly escaped in small volumes, but the deterioration of the flood capacity below greatly increases the amount, as well as the injurious deposits of sand and sediment upon lands subject to overflow during extreme flood. Since other information, the following changes have been made in the condition of the levees: All breaks on the right bank above Wilson's Landing have been repaired, and the levees raised 3 feet; at the railroad bridge above Marysville the right levee has been raised 6 feet, and extended 4 or 5 miles above the bridge. The left bank levee at Marysville has been raised 2 to 3 feet.

SUMMARY.

There is no mining of a very injurious extent above the Oroville group, although there are projected operations of considerable magnitude. The mines of the Oroville group are in a position to absolutely ruin the river as a navigable stream, and to work almost incalculable injury to the country below. There is no storage for their waste material in the bed of the river without obliterating the river at a point where, if obliterated, will turn the whole volume of floods loose upon a very valuable country; will inflict damages upon property in the immediate vicinity more valuable than the mines, not to mention the cost of the structures and treatment necessary for so expensive an undertaking.

YUBA RIVER.

Yuba River is a tributary of Feather River, entering this latter stream at Marysville 30 miles above its mouth. The Yuba drains about 1,330 square miles of the western slope of the Sierra Nevada, comprising portions of Sierra, Nevada, and Yuba counties. The extreme length of the watershed is about 60 miles, and extreme width, 36 miles; in addition to this length are about 11 miles of channel in the plains between the foot-hills and Feather River. In size Yuba River is the fourth in the Sacramento Valley. Its extreme low-water discharge is about 500 cubic feet per second,* mean winter discharge 1,500, and flood discharge 26,000 cubic feet per second.

Its drainage basin is naturally subdivided into five smaller ones, namely: North, Middle, and South forks, and Deer and Dry creeks; this last joins the river just as it leaves the foot-hills, the others having united in the mountains. The elevation of the basin of Yuba River is from 200 to 8,000 feet above tide. The precipitation upon it is probably not so great as upon the Feather.

Hydraulic mining operations upon Yuba River are upon a scale unknown elsewhere. The volume of water used in these operations is greater than that used on Feather, Bear, and American rivers combined; and the proportion of the material moved even greater. From the most reliable resources, the assessors' returns of 1880, and such corrections as can be made, there are used per year in the basin of Yuba River, 5,564,771, twenty-four-hour miner's inches of water. The State engineer estimates the duty of the twenty-four-hour inch at 3½ cubic yards. This estimate is certainly a reasonable one, and if erroneous, is a little lower than the actual duty; it gives 19,436,698 cubic yards as the amount discharged into the Yuba River and its tributaries each year. Although all may not be brought down during the same season, it is mined, and although quite a perceptible proportion is too fine to be stored, this full amount may be taken as that for which yearly storage is required. Any deficiency caused by the temporary lodging of coarse material in the cañons above, or in the transportation of fine material beyond the reservoir space, will be most likely compensated by material picked up en-route, or coarse natural wash.

The examinations upon this stream during the past season embraced three subjects:

1. The examination of the brush dam built in 1880 under the State Drainage Commission, the results of which examination have been submitted.

2. The survey and examination of the site for a storage dam at the Narrows, below Deer Creek.

3. The reconnaissance of the cañons of the North Fork and its tributaries, and a general inquiry into the condition of the hydraulic mines in its basin.

The South and Middle forks were surveyed in 1879 under the direction of the State engineer, and his report of 1880 contains a general description of their condition, &c.

The cañon of the North Fork was examined from 10 miles above Downieville to its junction with the Middle Fork, a distance of about 35 miles. The grade is from 90 to 70 feet per mile, with lighter reaches on bars; average width 125 feet, narrowest 80 feet, widest 300 feet. This last width occurs at Bullard's, Foster's, and Goodyear's bars, for a few hundred yards. The cañon is from one-quarter to one-third mile deep; its sides are principally slate and kindred rock, at angles of 30 to 35 degrees; in places steeper where harder rock occurs. It is much filled in places, and from very rough estimates contains several million cubic yards temporarily lodged. The annual supply of detritus is decreasing on the North Fork and its tributaries, not one of which but shows a marked tendency to deepen its channel by cutting away past deposits. This is notably the case upon Slate Creek, and upon the North Fork itself at Bullard's bar, and at the mouth of Deadwood Cañon; here a deposit, with a depth of 16 feet or more, has been evidently cut away 12 feet. The general testimony was that this occurred in the last five years.

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* This is not as small as the natural discharge would be; the large mining companies, the North Bloomfield, Milton, Eureka Lake, etc.; store quite large volumes of water during the winter and spring months, the use of which during periods of low water sensibly affects the discharge.

Storage.—The cañon of the North Fork is too steep for economical storage, and particularly undesirable when the river-bed claims and the better storage at "the Narrows," are taken into consideration; for this site not only commands storage for all storable detritus from the North Fork but for the greater portion from the others also. No specially desirable sites for dams occur, and none that would not involve at the outset the condemnation of mines in the bed of the river.

Tributaries of the North Fork receiving detritus.—The following streams receive the greater portion of the *debris* entering the North Fork:

Name of stream.	Small tributary or source of detritus.	Mining localities.
Slate Creek	Rabbit Creek	Laporte, Gibsonville, Howland Flat &c.
	Rattle Snake Ravine	Poverty Hill, &c.
	Small gulches	Portwine, Barnards, &c.
Cañon Creek	Little Cañon Creek	Eureka North, Craigs Flat, Merristown.
	Scales Cañon, &c	Scales Diggins, Poker Flat, &c.
Goodyear s Creek	Various small ravines	Eureka North, Monte Cristo, Chapparal Hill.

There are also numerous small gulches and tributary ravines which are transiently mined, and of which no account can be taken, except from the water returns, as the mining done is in many places pursued for a few weeks only, during the rainy season, and merely to prospect or do sufficient work to hold a claim. Of the streams mentioned above, Slate and Cañon creeks receive by far the greater portion of the *débris* and also the greater portion of the water.

The following amounts of water were used in each in 1880, according to the returns from county assessors. These amounts did not vary much in 1881, and may not be expected to vary much in the near future, except in the instances mentioned later, with the changes likely to take place at several mining localities:

Slate Creek used	485,630	Twenty-four-hour miners' inches per year.
Cañon Creek used	154,100	
Small tributaries and forks	331,200	
Total	970,930	

Much of the water is used in drift and quartz mines. It would be impossible to segregate it, as it frequently happens that both drifting and hydraulicking are practiced in the same mine, and no attempt has been made to separate the quantities; that which is used for hydraulic mining must have a high duty, probably 5 yards per inch in many cases, as in the majority of instances the material is rounded quartz gravel and sand, and the sluices have a heavy grade, 6 to 10 inches per 12 feet. The greater number of mines in operation during the time of the examination were washing river drift of recent origin, near the beds of the present rivers, and had a very low duty. One group of six near Logansville was carefully observed. They could not move over one yard per miners' inch; but the larger of the mines at Eureka North, and on Slate Creek must have a much higher duty, as the material is such as to be easily moved and the sluices have generally heavy grades. None were in full operation as late as July; so their operations could not be observed. It is safe, in estimating the amount from the North Fork, to include its water with that from the other forks, and to make an estimate of 3½ cubic yards for all.

Condition of hydraulic mining on the North Fork.—Hydraulic mining in the basin of the North Fork is more rapidly declining than observed elsewhere. More dilapidated, desolate-looking towns would be hard to find than some in this district. Towns dependent upon drift, quartz, or river-bed mines were generally prosperous. Should the past rate of decadence in hydraulic mining continue, a few more years will practically obliterate it. This is due to, first, the working out of many deposits, and, second, to the substitution of drift mining where the lava cap has been reached.

There were mines in operation at the following points:

Logansville, Italian Claim, Arratra & Co., Dutch Company (South Branch of the North Fork) use in the aggregate some 116,500 miners' inches, and move 70,000 cubic yards per season.

Criola and Logamanzina, Bush & Co., Uhlé & Co.—material very heavy, and coarse river drift.

Craycroft, Mowry and Eggleston (North Branch of the North Fork) mined a few months in each year; use in the aggregate 50,000 inches, and move 136,000 cubic yards per year.

Poker Flat, operating at three points; partly drift; use 17,050 inches and move probably one yard per inch, or 17,050 yards per year.

Eureka North, the scene of the most extensive past operations in the basin of the North Fork; some 200 acres mined off to a depth of 40 to 80 feet—four mines operated in the early part of 1881. Only one, the Moss, likely to work in the future. Use about 44,000 inches, and move about 220,000 cubic yards per year, but as the remaining deposit is not extensive will not last for many years.

Morristown and Craig's Flat use some 120,000 inches, and move about 400,000 cubic yards per season. The principal mining operations at these two points are carried on by a New York company. They are enlarging the capacity of their ditches from about 800 to 2,000 inches, so that an increase and continuance of the detritus from these localities may be expected. The other principal localities are mentioned under the heads of Slate, Cañon, and Goodyear's creeks.

Storage in small tributaries.—Slate Creek is very much filled up with *débris*, but is being gradually cut out again; its cañon was examined from opposite Portwine to the mouth. No particularly desirable storage reservoir nor site for dam occurs. The bed of the stream is occupied at many points by "tailing claims," which are leased to Chinese miners. No dam of any size could be built without interfering with one or more of these claims, which would increase the cost of storage far beyond the cost at other localities.

A site for a dam exists at a point a short distance above the crossing of the Forbestown and Scales Diggins road; here the creek is 80 feet wide, sides of syenite at angles of 30 degrees for a vertical height of 200 feet. The area above is graded for some 5 miles; will average 100 to 120 feet wide. There are four companies of Chinese miners at work in this space, and the whole creek bed is claimed. The conditions are such as to need no further consideration at present.

Cañon and Goodyear's Creeks.—These two streams were not examined throughout their full length, but were crossed at several points each, and observed sufficiently to ascertain: (*a*) that Cañon Creek presents about the same features as Slate Creek, and that the condition of the hydraulic mines upon it does not justify the erection of a storage dam especially for them. (*b*) That Goodyear's Creek is entirely too precipitous to afford storage, and that there is not likely to be sufficient mining upon it in the future to entitle it to further consideration.

As these streams are tributaries of the North Fork the same objections urged against storage in it become more potent when applied to tributaries, unless some special reason exists why they should not be regarded. As no such special reason has presented itself the subject may be dismissed.

THE SURVEY AND EXAMINATION OF THE NARROWS SITE.

For the storage of the bulk of hydraulic mining detritus entering the Yuba River at and above the mouth of Deer Creek, there exists good storage in the cañon of the river. To utilize this storage it will be necessary to erect a substantial obstacle or rough dam at the point known as "The Narrows." Here the river bed is contracted to a width of some 265 to 280 feet, with sides of hard blue trap, and having angles of from 50 to 32 degrees, continuing for upwards of 200 feet above the bed of the river. Above this height there exists an abundance of suitable stone. Samples of the various strata are presented. This material does not disintegrate, and can be quarried in blocks of from 1 to 15 cubic yards in size, or from 2 to 30 tons; this being about the sizes of the detached masses on the sides, some of which have rolled and slid into the bed of the river. The estimate given in the subjoined table is for a series of dams, having a crest width of 20 feet, slopes 1 on 1 and 1 on 4. To each dam is added 10 per cent. for sinking, and each dam, after the first, is estimated to commence 10 feet below, and to extend 25 feet above, the crest of the preceding dam. The first dam is estimated at 75 feet high, in order to at least cover the amount of material coming down any one year, which, as will be shown later, is about 17,133,000 cubic yards, directly discharged by the mines, and liable, during seasons of extreme flood, to be increased largely by the washing down of temporarily lodged material.

The storage space above is in the bed of the river, which averages for 44,500 feet 300 feet in width, with sides sloping at angles of 30 to 35 degrees; this last angle is used in estimating the storage. The grade as shown from the surveys in 1879 by the State engineer is from 22 to 23 feet per mile throughout the distance given above. Higher up, the grade of the main Yuba is about 30 feet per mile, with considerable storage not yet surveyed. In the South Yuba the grade is about 50 feet per mile and also considerable storage area. This additional storage is included in the table, and an addition of $50,000 is made to the estimate to cover the cost of property that may be damaged. From an intimate acquaintance with the locality this amount is deemed certainly just, if not ample to cover the value of this property. The grade that will be assumed by the material stored back of the proposed dam cannot be forecast; it cannot easily be less than 14 or 15 feet per mile (the grade assumed lower down where the river is wider); hence the storage capacity is estimated upon that grade, and includes that above the mouth of the South Yuba. Should the grade be steeper and should the dams be built higher, the space above will be utilized to greater extent, dependent upon the excess of grade over 14 feet per mile.

Table showing estimate for the Narrows Dam.

Grades of storage prisms, 14 feet per mile.

Number of dam.	Height.	Total height.	Contents of dam.	Storage capacity.			Ratio of stone in dam to stored material.	Cost of dam and reservoir.					Cost per yard of stored material.	Number of years the storage will last.
				In the Yuba, below the South Fork.	Probable additional storage in forks.	Total.		Cost of stone in dam per cubic yard.	Cost of dam.	Contingencies 10 per cent.	Damages.	Total cost.		
	Feet.	*Feet.*	*Cubic yards.*	*Cubic yards.*	*Cubic yards.*	*Cubic yards.*							*Cents.*	
1	75	75	204, 345	25, 518, 565	....	25, 518, 565	124	$1 00	$204, 345	$20, 434	....	$224, 779	0. 85	1. 4+
2	25	100	59, 496	17, 753, 438	7, 000, 000	24, 753, 438	416	1 25	74, 370	7, 437	$50, 000	113, 807	0. 45	1. 3
3	25	125	65, 989	20, 695, 382	10, 500, 000	31, 195, 382	457	1 25	82, 486	8, 248	....	90, 734	0. 29	1. 8-
4	25	150	73, 471	23, 637, 326	13, 500, 000	37, 137, 326	491	1 50	110, 206	11, 020	....	121, 226	0. 33	2. 1
5	25	175	81, 958	26, 579, 270	15, 000, 000	41, 579, 270	507	1 50	122, 937	12, 293	....	135, 230	0. 33	2. 4+
6	25	200	89, 918	29, 521, 214	17, 000, 000	46, 521, 214	518	1 50	134, 877	13, 487	....	148, 364	0. 32	2. 7+
7	25	225	98, 000	32, 463, 158	20, 000, 000	52, 463, 158	533	1 50	147, 000	14, 700	....	161, 700	0. 31	3. 0+
Total	.....	....	673, 177	176, 168, 353	83, 000, 000	259, 168, 353	382	....	....	....	....	995, 840	0. 39	15. 0

The average cost of storage per yard is over one-third cent, or $0.0039.

It has been shown that débris may be expected to enter the Yuba River at the rate of about 19,400,000 cubic yards per season, and that some 5,564,771 miners' inches of water are used; of this amount about 669,586 inches are used below the site of the dam, or at Smartsville, Sicard Flat, and on Dry Creek; the remainder, 4,895,185, is used above the dam, and at the rate of 3½ yards per miners' inch will move some 17,133,000 cubic yards. This entering above the dam may be taken as the annual amount requiring storage. No deductions are made for temporarily lodged material, nor light unstorable material, for these deficiencies are probably more than compensated for, as heretofore mentioned. By reference to the table it will be seen that the first 75-foot dam will about furnish storage for the débris coming down in one and four-tenths seasons; the second 25 feet develops about the same capacity; the others may be erected at a slower rate than 25 feet per year; the group running up to the height of 200 feet furnishes storage for some fifteen years, at an average annual cost, after the first two years, of about $50,600.

The material moved by the 669,586 inches used below this dam must be provided for below. Storage space exists and can be utilized by the construction of a dam at De Guerre Point or by repairing the brush dam built under the State Drainage Commission. Since the examination and report heretofore submitted regarding this structure a large portion has been burnt—hence it may be advisable to adopt the site at De Guerre Point; this admits of a dam 5,552 feet long and 35 to 40 feet high. It could be built in partial heights as storage was needed. It may perhaps be desirable to erect this lower structure first; but the erection of a dam at both points is the most desirable, as a considerable volume of sand may escape the upper dam in addition to the 2,344,000 cubic yards which may be moved by the 669,586 inches heretofore mentioned.

The following estimate in tabular form is made for a dam at this point. The first dam is estimated to lay on a grillage 3 feet thick, and to be 10 feet high, with slopes of 1 on 1 and 1 on 3. The crest width is 10 feet; the second and third dams are of similar shape and are respectively 6 and 5 feet in height, resting on grillage 3 feet thick.

The erection of this dam or the repair of the brush dam will avoid the necessity for a dam at The Narrows for some years.

Stone is abundant on the south bank, and a limited quantity at hand on the north bank; the material is similar to that at The Narrows.

The estimates for retaining-capacity are based on a grade of 10 feet per mile; the lightest grade existing in the reservoir space above is 10.5 feet per mile. No estimate is made for the extension of material over the flat lands known to exist above in limited area.

The estimate is based upon work done in July, 1880, under the State engineer.

This series of dams is estimated to cost per linear foot as follows:

1. *Dam 10 feet high, 10-foot crest.*

Excavation, 8.888 cubic yards, at 12½ cents	$1 11
Covering mattress, 1.11 cubic yards, at 12½ cents	14
5,11 square yards mattress, at $1	5 11
Grillage, 3.5 logs 20 feet long, 15 to 8 inches diameter, 2 logs 30 feet long, 15 to 8 inches diameter	5 50
Laying, fastening, &c	2 50
12.223 cubic yards rock, at $1.35, 10 per cent. added for settlement	16 50
Cost per foot	30 86

2. *Dam 6 feet high, 10-foot crest.*

3 trees 8 to 15 inches diameter, 20 feet long, at $1	$3 00
Placing, fastening, &c	1 00
5.3778 cubic yards stone, at $1.50	8.067
Cost per linear foot	12.067

3. *Dam 5 feet high, 8-foot crest.*

3 logs 15 to 8 inches diameter, at $1	$3 00
Laying, fastening, &c	1 00
3.66 cubic yards stone, at $1.50	5 49
Cost per foot	9 49

Table showing estimate of cost and effect of dams at De Guerre Point.

Number.	Height.	Length.	Cost.	Cost, contingencies, damages, &c.	Total cost.	Storage capacity.	Cost per cubic yard stored.
	Feet.	*Feet.*	*Per foot.*			*Cubic yards.*	
1	10	5,552	$30 86	$71,325 72 17,132 57 20,000 00	$208,458 29	24,800,000	$0.0084
2	6	5,552	12.067	66,995 98 6,699 59	73,695 57	19,500,000	.00378
3	5	5,552	9 49	52,688 48 10,537 69	63,226 17	17,500,000	.00361
Total	21	....	....	345,380 03	345,380 03	61,800 000	

Succeeding dams will cost about the same as the third, and will increase in storage capacity; the area available above is about 4.25 square miles, or 2,720 acres. To the cost of the first dam is added $20,000 to cover the condemnation of several pieces of property in the area above the dam; to the cost of the third are added contingencies of 20 per cent., as it will then, if not before, be necessary to erect a short piece of dike on the south bank of the river. This dike may be shortened and thrown on better ground by shifting the south end of the dam some 1,400 feet up stream. The change will not materially affect the length nor the amount of material in the dam, but will leave the northern end on lower ground, and necessitate that end of the structure being higher; unequal settlement may then be expected, and a concentration of water at the point of greatest settlement. The line of dike which would be necessary is very short, not over 3,000 feet at the farthest, and need not exceed 5 feet in height for the second dam, with successive additions as the dams are carried higher.

The dike line is much improved by shifting the south end of the dam 1,400 feet above the point shown in the map of the locality as being the south end of the dam line. The small stream entering just above the dam may be passed around the dike, into the river below the dam, or be included in the reservoir space by running the dike on its south bank to equally high ground; the latter is respectfully suggested whether the dam line be shifted or not.

The advantage of having the flanking dike on the best and highest ground more than counterbalances the disadvantage of the unequal height of dam, for this latter affects only the first dam, whilst the former will influence all in the series and the maintenance of the structure in the future. Another item in favor of shifting the line is the fact that this 1,400 feet is saved in haul of stone, although lost in other material. No estimate need be made for the dike for the first dam, whatever be its position, and the need for it will be very slight in the second; subsequent dams, however, will require dikes.

BEAR RIVER.

Bear River, as will be seen from the accompanying map, lies between the South Fork of the Yuba and the North Fork of the American; the headwaters of these streams reaching beyond those of the Bear and interlacing behind it. This stream consequently does not head at the summit of the Sierra Nevada. Its drainage area is generally estimated at about 300 square miles; it is the smallest of the four streams treated in this report, but has more detritus now temporarily lodged in its upper portion and tributaries than any of the others, and within its basin are some of the most important hydraulic mines in the State.

Bear River leaves the foot-hills near Camp Far West and flows through the plains for a distance of some 15 miles to the Feather River, 3 miles above Nicolaus. On its right bank, just as it leaves the foot-hills, are situated some of the most fertile farms in the State. The destruction of the other lands near its mouth has been given in your report of February 20, 1880.

Entering Feather River in its navigable portion and carrying a large amount of débris, the injurious effect of Bear River is very marked. From such few sediment examinations as were conducted in 1878–'79 by the State engineer department, its waters show the presence of a greater amount of suspended material than any known stream. From this it will seen that for the protection of both navigable rivers and agricultural lands there is urgent need for remedial measures upon this stream.

Storage on Bear River.—To select the most available point or points for storage, a reconnaissance was made of Bear River from Camp Far West to the dump of the Polar Star mine, a distance of 40 miles, and upon recommendation that portion of this distance between the mouth of Greenhorn and Long Bar was surveyed and the most desirable sites for dams examined. A map and profile of this portion of the river is herewith submitted; these show the general character of the stream and the grades existing throughout this portion of the river, and the subjoined table gives these grades.

Table showing grades on Bear River.

From—	To—	Distance.		Total fall.	Grade per Mile.	Condition of cañon.
		Feet.	*Miles.*	*Feet.*	*Feet.*	
Dutch Flat Road	Nevada Railroad Bridge	....	10	550	5.5	Filled and graded.
Nevada Railroad Bridge	Bear River Dam	4,672	0.88	26.4	29.5	Do.
Bear River Dam	Kinder Dam	7,027	1.3	89.8	73.9	Partly filled and graded.
Kinder Dam	Mouth of Kinder Cañon	840	0.16	22.2 22.0	147.8	Dam 22 feet high, cañon clean.
Mouth of Kinder Cañon	Van Giesen Dam	58,000	10.9	278.6	25.3	Filled and graded.
Van Giesen Dam	Wolf Creek	20,000	3.8	308.6	79.2	Clean cañon.
Wolf Creek	Head of Steep Cañon	16,670	3.1	339	105.6	Do.
Steep Cañon	Long Bar	15,595	2.9	411.8	142.5	Do.
	Through Long Bar	1,735	0.33	14.3	43.3	Slightly filled.
Long Bar	Camp Far West	About.	8	327	40.9	Do.
Camp Far West	C. P. Railroad Bridge	....	5	40	8.0	Filled.
C. P. Railroad Bridge	Berry's	....	9	49.4	5.5	

The sites examined were five in number, namely, at the Kinder Dam, at Ragsdale's Pipe, at Van Giesen's Dam, at Station 949, and in the cañon just above Long Bar; of these a study of the map and profile shows that the first three are the only ones to be considered.

The first of these at Kinder Dam is abandoned for the following reasons:

1. There is too much private property to condemn.
2. A dam high enough to store much material would interfere with existing public works.

Under the first head are the following properties and values:

(*a*) Kinder Dam	$20,000
(*b*) Changing headworks of Bear River Ditch	3,000
(*c*) Harrison & Co.'s mine	6,000
(*d*) Lands above railroad bridge	5,000
(*e*) Mine in bed of river above railroad bridge	10,000
	44,000

Under the second there would be—

(*a*) Raising Crandall's Bridge.

(*b*) Raising and strengthening the railroad bridge.

These would involve an outlay of possibly $20,000 or more. This gives a total of $64,000, which is considered a moderate estimate for the damages which would be claimed, were a high dam projected by the government at this point. No further consideration need be given the subject, further than to observe that at some time in the future, when most of this property shall have been obliterated, it may be desirable to construct a dam at this point.

The site at Ragsdale's Pipe presents several favorable points; the average width of the river as shown on the map is slight, and the sides are high and steep, but it is *above* the widest portion of the river channel; the river bed immediately above the site is too narrow to afford the best storage, and precautionary measures would have to be taken to secure the foundation, as the deposit of sand and gravel here has considerable depth, perhaps 10 or 15 feet.

The location at Van Giesen's Dam is desirable principally on account of the greater storage area, for availability and suitability of stone, for the excellent foundation, and for the lighter property values in the reservoir space. As will be seen from the map and profile this dam is situated at the lower end of a lightly graded and filled portion of the river; the space above is filled as far back as the cañon, immediately below the Kinder Dam, and is wider than any other portion of the cañon of equal length; the greatest width is in the lower portion of the reservoir space, where the maximum depth of deposit may be expected. The subjoined table presents what is considered a fair estimate of the extent of property damages.

(*a*) Van Giesen's Dam	$3,000
(*b*) Combé's Farm	5,000
(*c*) Small mine (nominal)	500
(*d*) Raising Ragsdale's Pipe	500
(*e*) Small strips of land on each side of the river	1,000
	10,000

The grade of the river in the storage area, as determined by the survey and given on the profile, is 25.34 feet per mile. The effect of an old log dam (just below the point chosen for the storage dam) was to back detritus upon a grade of 19.38 feet per mile, and in the absence of better data this grade is adopted for that which will be assumed by the stored material. The material available for the structure here is of good quality, a very hard trap, with streaks of feldspar and kindred rock. The haul need not exceed 200 yards. Samples of the various qualities of stone available here are submitted, marked, "Stone, Van Giesen's Dam."

The accompanying sections show the shape and general dimensions of the dam and the width and slopes of the cañon, and the drawings show the two plans submitted for a dam at this point. The first is a stone dam 30 feet high; the second a crib dam of the same height; the succeeding dams are estimated to commence 10 feet below and to extend 10 feet above the crest of the preceding dam, and in the case of the crib dam to cover the wood-work as shown in the drawing. The cost of covering the lower face of this dam with stone (as will ultimately be necessary), together with the cost of the crib work, exceeds the cost of the stone dam.

In the event of the erection of a structure at this point a modification of this method may be found necessary, for the owner at the time of the survey was constructing a dam 19 5 feet high, which if completed will fill to the crest with débris this winter. The estimate submitted below will cover this contingency.

Table showing estimated cost and capacity of Van Giesen Dam—stone.

Number.	Height.	Volume of dam.	Cost per cubic yard.	Cost.	Total cost.	Estimated storage.	Remarks.
	Feet.	*Cu. yds.*				*Cu. yds.*	
1	30	10,725	$2 00	$21,450 00 10,000 00 3,145 00	$34,595 00	6,735,000	Damages, $10,000; contingencies, 10 per cent., $3,145.
2	10	5,688	2 00	11,376 00 1,137 60	12,513 60	5,366,000	Ten per cent. contingencies.
3	10	7,447	2 00	14,894 00 1,489 40	16,383 40	9,270,000	Do.
4	10	9,300	2 00	18,600 00 1,860 00	20,460 00	10,215,800	Do.
Total	60	....	....	....	83,952 00	32,086,800	

The estimated cost of storing one cubic yard is as follows:

1 dam	$.0056
2 dams	.0021
3 dams	.0016
For the series	.0029

For the alternate plan of construction the drawing sufficiently explains the method, size, and shape of the structure. It is thought best to tie the crest of the crib-dam to the solid bed with iron rods, as shown in the drawing.

The table below shows the estimate for this dam.

Table giving estimate for crib-dam at the Van Giesen Site.

Number.	Height of dam.	Volume of dam.	Cost per yard.	Cost.	Total cost.	Estimated storage.	Remarks.
	Feet	*Cu. yds.*				*Cubic yards*	
1	30	8,400	$1.50	$12,600 00 10,000 00 2,260 00	$24,860 00	6,735,000	$10,000 damages: 10 per cent. contingencies.
2	10	17,305	2.00	34,610 00 3,461 00	38,071 00	5,866,000	Do.
3	10	7,447	2.00	14,894 00 1,489 40	16,383 40	9,270,000	Do.
Total	50	....	....	....	77,825 40	21,871,000	

The average cost of storing 1 yard by this series of dams is $,00356. The increased cost is in the covering a dam 30 feet high with stone on the lower face, which, as shown in the section and estimate, requires a greater volume and cost than the stone dam.

From the following data it is estimated that the duty of a miner's inch on Bear River is about 4½ cubic yards.

In the case of Keys *vs.* The Little York Mining Company et als. the general testimony was that a twenty-four-hour miner's inch moved 3.5 yards, but Mr. Louis Janin, mining engineer, testified that of top gravel there might be moved from three to six times as much as of bottom gravel. As the top gravel bears a very respectable ratio to the amount moved it largely affects the result. T. B. Ludlum testified that from 2 to 6 cubic yards were moved; taking the mean here, gives 4 cubic yards. Mr. James D. Hague accepts 7 cubic yards in estimating upon the San Juan Ridge.

The State engineer, in his report of 1880, estimates 3 yards as the average duty, but the direct measurements upon which this estimate was based were confined to a few mines on the south bank of Bear River, where the amount of water used is smaller and the material coarser than on the north bank. There is no apparent reason why a miner's inch on the north bank of Bear River, where most of the water is used and where the largest deposits are worked, should not have as high a duty as on the mines of the American, where an estimate of 4½ cubic yards per inch is given. Should there be an error it is on the safe side in the estimate, and can do no greater harm than supply too great storage, for any one season, a mistake which will be forgiven by any of the parties interested in the matter.

From the assessor's returns of 1880 there were given 1,117,082 miners' inches as being used in the basin of Bear River, all of which enters above the site of the Van Giesen Dam; there was no material change in this during 1881. This amount of water will move 5,026,868 cubic yards of material. As in the case of Yuba River, no deductions are made for material escaping, for although there is much that will go over, or lodge temporarily and perhaps permanently, there will be an abundance of material from natural wash and from material left on the way in former seasons to supply this deficiency; consequently, from 5,000,000 to 5,250,000 cubic yards may be expected to enter the reservoir per season. Upon reference to the foregoing tables it will be seen that the first and second dams will about supply storage for one season each, and that the third will more than supply storage for the succeeding season, provided that the present rate of mining continues.

There may be additional storage provided here by increasing the height of the dam, or by the construction of works at other localities, as may be deemed best from future experience and farther knowledge.

The erection of a dam at this point, or some other in the cañon of Bear River, is very essential, even should the brush dam at Johnson's Crossing be repaired.

There is no large amount of *débris* below the site of the Van Giesen dam until the deposits at the mouth of the cañon are reached; hence, a dam here would secure the retention of a large portion of the 86,000,000 cubic yards, estimated, as now lodged in the cañons, and which, to a great measure, must be swept out in the near future.

An estimate for the repair of the brush dam at Johnson's Crossing is appended to the report heretofore submitted. In treating the Bear River, it may be well to call attention to the large amount of land of low value on the left or south bank, and its suitability for a storage reservoir; more has already been spent by the State and private parties in attempts to protect this land from destruction than the land is worth. The ultimate fate of this land is beyond question; it must be destroyed in the natural order of events, for the forces at work above are the same that have caused the destruction of larger and far more valuable tracts elsewhere, and these forces are aided by the hydraulic miner to such an extent as to accomplish in a few years the same results which the herder and the lumberman only accomplish in centuries, or at least, decades. Bear River may be made to produce a desirable result by training it into American Basin and using its sediment to warp that low area above the reach of the injurious and prolonged floods to which it is now subjected.

This is probably the only way of *entirely* removing its injurious effects from Feather and Sacramento rivers. For although the erection of dams in the cañon will avert some, probably the greater, portion of injury likely to occur in the near future, much will still follow unless more extensive and costly works are executed below. This matter has not been examined into as yet; its farther consideration is respectfully suggested as worthy of future attention.

AMERICAN RIVER.

The general character of the water-shed of the American River has been described in Appendix C of your report of January 10, 1881; it is not necessary to repeat it here.

The work during the past season on the American was confined to a reconnaissance on foot of the forks and of the most important of the tributaries of the South Fork, and an examination of the mines on the Georgetown and Placerville divides. The work done was as follows: Reconnaissance of the North Fork, from Gold Run to Mormon Island, a distance of about 40 miles; of the Middle Fork, from Ford's Bar to the mouth, a distance of about 18 miles; of Cañon Creek for 8 miles; of the South fork, from Chile Bar Bridge to Folsom, a distance of about 45 miles; and of the following tributaries of the South Fork: Johnstown, Greenwood, and Weber creeks; in the aggregate, 30 miles, or 140 miles in all on the American.

Hydraulic mining on the American, and the character of detritus.—The principal hydraulic mines in the basin of American River are those of the North and Middle forks.

Both of these streams are much filled up, and are the recipients of 5,000,000, and possibly 6,000,000, cubic yards of material yearly. The general character of this material has been frequently described, but it may not be out of place to compare it with that from other streams.

Feather River hydraulic mining, so far, is of so limited a nature as to afford a material which, when mixed with the surface wash, forms a not undesirable soil. The material from the Yuba and Bear rivers has a most injurious effect upon land, and is of an absolutely unfertile character, as shown, first, by its effect upon soils; and second, by the analysis made by Professor Hilgard, of the State University. That from the North and Middle forks of American River is of about the same nature, and is principally sand and gravel, mixed with cobbles and pipe clay. The material reaching the Sacramento is very fine gravel, sand, and sediment.

The American, unlike Yuba and Bear rivers, is muddiest during freshets, particularly the earlier ones; this is due to the sweeping out of the deposits of the past low-water season, to the greater extent of mining operations during the rainy season, and to the large amount of natural denudation. In this respect it resembles the Feather.

On the South Fork the character of mined material is entirely different. The gravel deposits are largely covered by a lava-cap from fifty to several hundred feet in depth, which prevents profitable hydraulic mining. There is another class of material worked by the hydraulic process; this is a decomposed slate, sometimes called "porphyry," carrying veins or seams of gold-bearing quartz. These veins are mined more extensively in the basin of the South Fork than observed elsewhere, and constitute the principal mining properties around Georgetown and Greenwood. The gold is extracted by both the hydraulic and drift process. When extracted by the hydraulic process the work is always slower than when gravel is worked; the flat slate pieces are not easily transported, and consequently a very large percentage of the material mined is left on the dumps; in many instances it was estimated that 80 per cent remained.

These dumps slowly decompose and are said to be valuable enough to admit of being reworked.

In some instances the tailings are reworked in a stamp mill-like quartz. The fine material produced in this manner or in the gradual decomposition of this slate is not so injurious to land, and when wet and then dried does not cake nor form a stiff bricklike mass, like the pipe-clay of the Bear and Yuba River mines. When mixed with the débris from surface or placer washings it forms a valuable soil, and is in frequent instances caught by light brush dams, or diverted on flat lands to form valuable meadow or orchard land. This friable material and the natural wash when mixed with the unfertile and injurious material from the North and Middle forks causes "American River sediment" to be used as the least undesirable for filling lots in Sacramento City.

The detritus from the mines on the South Fork is of so fine a nature as not to admit of economical storage, and is spread out over so large an area as not to cause much damage to navigable rivers.

The project of storage will be mentioned further on.

The Cañon of the North Fork.—This cañon was examined from about a mile above Ford's Bar, or opposite Gold Run, to Folsom. At the upper point the cañon is from one-fourth to one-half mile deep; the sides are of slate, at angles of about 35 degrees.

The bed of the river is about 125 feet in average width and composed of cobble stones and gravel from the mines around Gold Run and other localities.

The grade of the cañon for the first 9 miles, or from Ford's Bar to Rice's Bridge, is from 35 to 46 feet per mile, as shown by surveys by Mr. Wren, and is filled and graded with débris. Below this there is a narrow, steep, and clean cañon for a mile or more, and then the river widens to an average width of about 250 feet; is filled and graded to about 23 feet per mile for 20 miles, to a point about 2½ miles above the junction of the Middle with the North Fork. The distance from Rice's Bridge to the junction is about 20 or 22 miles.

In this reach enter Indian and Shirttail creeks and other small tributaries, bringing the débris from the mines on the Forest Hill Divide. At the lower end of this reach are several sites for dams, which will be described later. There are probably 20,000,000 or 25,000,000 cubic yards of débris lodged in the North Fork above the Middle Fork.

The Middle Fork joins the North Fork at a point about 2¼ miles northeast of Auburn; the two streams were delivering about 3,500 to 4,000 miners' inches each, or from 80 to 100 cubic feet per second; the water of each stream was only slightly muddy when compared with the Yuba and Bear, but very much changed from its original clear condition as observed above mining operations.

The stream is known as the North Fork to the junction of the South Fork at Mormon Island, 3 miles above Folsom. The distance from the junction of the Middle Fork to Folsom is about 23 or 24 miles; in this distance there are three valuable bridges besides the bridge at Mormon Island over the South Fork. In the bed of the river are several mines, mostly leased to Chinese. About 20 miles above Folsom the North Fork Ditch Company was having a dam built across the river, some 280 feet long and about 30 feet high, to divert water into the ditch passing down the right bank; this dam was not completed, but was nearly so. It was built to replace the one just above, which was torn out by the flood of February last. The remains of the old dam showed plainly; it was about the same dimensions of the new one, and backed material on an even grade for some 2 miles; the deposits left on the sides showed that the dam whilst intact was filled to the crest. When the dam broke, the greater portion of this material was swept out, the coarsest of it being deposited in bars extending at intervals for several miles below.

There are also orchards at and near Lacy's Bar and a very valuable one just below Gwyn's Bridge, 5 miles southeast of New Castle; these orchards are near the river, and would be covered in case large storage dams were erected.

In this reach below the Middle Fork there are several good sites for dams, above which great storage could be developed; but the properties above mentioned would render the project of storing detritus here too costly for present consideration.

The formation from a short distance above Gwyn's Bridge to Folsom is granite. The sides are steep near the river, but fall away into low rounded hills 300 to 500 feet above the river. In the portion of the river between the junction of the South Fork and Folsom there are two sites for dams. One of these is about a mile below the South Fork; here the section is about 90 feet wide, with granite sides extending for 70 feet above the river bed, at angles of 30 and 35 degrees. A dam here would develop storage of considerable volume, but would be very costly on account of the destruction of the village of Mormon Island, mining property, and the bridge. A short distance below this is a more desirable site for a dam 40 feet high. Here the Folsom Water Power Company proposes to erect a dam 40 feet high, to bring water into Folsom at an elevation of about 80 feet above the river. This dam was commenced in 1866 and that portion erected remains in good order.

It is proposed to complete this dam in the next year or two, the company having secured the convict labor from the State penitentiary just below.

The cañon from the junction of the Middle Fork down to Folsom is practically clear of débris of moment; it presents evidence of having carried large quantities, as there is scarcely a niche in the bowlders on the sides which is not full of sand or fine gravel; the interstices are all smoothed over, and in some localities bars are formed, but the filling is slight for a débris-carrying river, particularly when compared with that above or in Yuba or Bear rivers.

The grade of the river through this reach is about 22 feet per mile; the large volume of water from the North and Middle forks has carved out the greater portion of the material passing down either stream.

Storage in the North Fork above the mouth of the Middle Fork.—The cañon just below Rice's Bridge has been mentioned as being narrow, with precipitous rocky sides, and is suitable in some respects for a dam. The average width is about 90 feet; sides slope at angles of 37 and 35 degrees; material on the sides, a flinty trap. Area available above about 10 miles long, graded with débris to a slope of from 35 to 46 feet per mile and averaging 130 feet in width.

The objections to this site are serious:

1. Is not low enough down to catch all storable material entering the North Fork above the Middle Fork.
2. Would interfere with Rice's Bridge.
3. Would cover two patented claims, viz, the V.V. Company's claim, 3,000 feet long; River Construction and River Placer claim, value, $10,000, and Dodd's Claim, value $1,000, for which the patent is pending. It is not considered necessary to further consider this point.

The second site examined was at the head of the narrow cañon, commencing some 2¼ miles above the Auburn and Forest Hill or North Fork bridge. Here the width of the cañon is about 125 feet; sides slope at angles of 25 and 65 degrees for 45 feet. Material hard, durable trap; the cañon bottom is slightly filled; here the foundation is not very good.

The dam could be economically built to a height of only 45 feet; an overflow could be constructed in solid rock on the left bank.

Storage area above about 18 miles long, graded to about 23 feet per mile, and averaging about 275 feet wide, with sides of about 25 and 30 degrees.

This site is below all hydraulic mining operations on the North Fork.

The objections to this site are—

That the dam can be economically built to only 45 feet in height, and the foundation is not as good as is desirable.

The third site examined is about 1 mile above the bridge above mentioned. The average width of the cañon is about 75 feet; sides slope at angles of 42½ and 32 degrees for 150 feet above the bed of the river.

Material for dam, hard gray trap above the site of the dam on each side, or on the right bank 300 feet up stream; foundation, rock. This point has the advantage over the preceding site as follows:

Foundation is better—site more accessible--can be built higher, and therefore develop more storage—less material will build a higher dam.

The storage area above is estimated as follows: length available 20 miles, average width 250 feet, grade 23 feet per mile, slopes of sides 25 to 30 degrees.

From the present grade existing on Bear River, as determined by the survey, and the grade of 19.33 feet per mile established by the old Van Geisen's Dam, it ts estimated that the material on the North Fork above the junction of the Middle Fork will assume a grade of 18.2 feet per mile, and the estimate for storage is based upon that figure.

The present average grade is, as before given, about 23 feet per mile for the whole distance; the grade in the wider and lower portions of the storage space is probably lighter. Bear River in the corresponding reach has an average fall of 25.3 feet per mile, filled and graded with débris similar to the North Fork.

The following estimate is made for a series of dams at this site:

Table showing approximate estimate of the size, cost, and effect of a dam above North Fork Bridge.

Number.	Height.	Volume.	Storage capacity.	Cost per cubic yard.	Cost.	Total cost.	Cost per yard, stored.
	Feet.	*Cubic yards.*	*Cubic yards.*				
1	30	12,213	5,500,000	$1 25	$13,266 25 1,326 62 10,000 00	$24,592 87	.0045
2	10	5,500	5,400,000	1 30	7,150 00 1,430 00	8,580 00	.0016
3	10	6,420	7,600,000	1 40	8,988 00 1,797 60	10,785 60	.0014
4	10	7,340	10,290,000	1 50	11,010 00 2,202 00	13,212 00	.0012
Total	60	31,473	28,790,000			57,170 47	.0020

According to the assessor's returns, there were 512,773 twenty-four-hour miners' inches of water used on the North Fork in 1880. From the fact that several of the ditches on the Forest Hill Divide have been reported to be enlarged, it is probable that the amount of water used in 1881 and for the next few years will be about 600,000 twenty-four-hour miners' inches; with the duty of 4.5 cubic yards, the amount moved and requiring yearly storage will be 2,700,000 cubic yards.

As the grade estimated for the storage reservoir is probably steeper than it will at once assume, we have about storage for the first season, allowing for settling and lighter grade in the first 30-foot dam.

The first dam may be decreased slightly in cost by the erection of a crib-dam of the same height; but with slopes of 1 on 1 and 1 on 2, this dam will require about 10,000 cubic yards. In the table, allowance is made for settlement; each succeeding dam is estimated to commence 10 feet below and extend 10 feet above the crest of the one just preceding, and to this 10 per cent. is added.

Storage below the mouth of the Middle Fork.—There are several points at which dams may be erected below the mouth of the Middle Fork, and one below the mouth of the South Fork. An estimate is made for a point about 2½ miles below Gwyn's Bridge. A dam at this point would store material in a river-bed averaging 400 feet wide back to Gwyn's Bridge, and 200 feet wide for some 8 miles farther; the sides, from the dam to a point some 5 miles above, slope at angles of about 15 degrees, with many broad ravines; above this, at angles of from 20 to 30 degrees.

The river at the dam is about 100 feet wide, sides sloping at angles of 30 and 35 degrees; the site admits of a dam 100 to 125 feet high.

The following table gives an approximate estimate of the storage capacity and cost of dams at this locality.

It is observed that these dams, if erected, will do away with the necessity for the dam heretofore mentioned on the North Fork; and also for dams on the Middle Fork and Cañon Creek, mentioned later.

Table showing approximate estimate of size, cost, and effect of dams on the North Fork, two and a half miles below Gwyn's Bridge.

Number.	Height.	Contents of dam.	Cost per cubic yard.	Cost.	Total cost.	Storage capacity.	Cost per cubic yard, stored.
	Feet.	*Cubic yards.*				*Cubic yards.*	
1	50	43,800	$1 25	$54,750 5,475 40,000	$100,225	6,000,000	.0167
2	25	33,000	1 35	44,550 4,455	49,005	9,000,000	.0054
3	25	41,400	1 40	57,960 5,796	63,756	13,000,000	.0049
Total	100	118,200			212,986	28,000,000	.0076

The sum of $40,000 is added to the cost of the first dam to cover the cost of condemnation of farming and mining property, and raising Gwyn's Bridge. The estimate for storage is very rough, as there are no maps of any pretension to accuracy, and the area available is very irregular, and exceedingly difficult to approximate from a mere reconnaissance; it is thought, however, that the figures given are below rather than above the probable quantity. This dam would interfere with the North Fork Ditch when it reached a height of 80 or 100 feet or more, but the interference could be made a benefit after the dam reached above this height, as it would then avoid the maintenance of some 9 or 10 miles of ditch; at the height of 100 or 125 feet an overfall in granite could be constructed on the left bank. As for the site below the South Fork, the condemnation of property at Mormon Island, and the interference with the county bridge, is sufficient to swell the cost beyond a reasonable figure.

THE MIDDLE FORK.

The Middle Fork was examined from its mouth to Ford's Bar, a distance of about 18 miles.

The cañon for the first 3 miles above the mouth is steep and comparatively clear of débris. Some 3 miles above the mouth are situated a group of mines, some of which are now being worked or prospected with favorable outlook to those owning them.

Just above the lower one of these mines is a narrow and steep gorge in the river, suitable for a dam some 40 feet high and 175 to 200 feet long. The existence of mining property above entirely precludes the use of this site for a storage dam.

The following property values below the storage plane will prevent further consideration of this point:

Mammoth Bar, value from $50,000 to $75,000.
Hoosier Bar, value $25,000.
Sardine Bar, value $25,000.
Buckeye Bar, value from $50,000 to $100,000.

For about 8 miles above the gorge just mentioned the river has an even grade of about 18 to 20 feet per mile, and is from 900 to 300 feet wide, the sides of the cañon sloping at angles of about 30 degrees. Many points of this portion of the river are owned and mined during low-water. These mines have certainly as flattering prospects as those on the ridges above and needing storage.

At the head of this reach of 8 miles are a series of mines which may be generally designated as the Oregon Bar Group. These are principally what are known as "seam diggings"; or seams of gold-bearing quartz in a decomposed talcose slate. These mines are worked during the wet season and move an insignificant amount of material, the greater portion of which lodges on the dumps before reaching the river.

From Oregon Bar to Ford's Bar, about 8 miles, the river is in a narrow and steep cañon, comparatively clean of débris, and affording rather limited storage, although there are several sites for dams which could be cheaply built, owing to the steepness of the sides and the existence of building material in abundance immediately above the site of the dam.

In the absence of available storage in the Middle Fork below all sources of débris, an estimate is appended for a dam above Oregon Bar or a short distance above the mouth of Cañon Creek. This will leave the material entering through Cañon Creek, at Oregon Bar, from Jones Hill, and one or two minor points lower down without storage; and this material must be otherwise provided for; the débris from these sources, however, is light and admits of being transported very far, a condition which does not favor its being stored in the mountains. The cañon at this site is about 90 feet wide, sides slope at angles of 55 and 42 degrees. This dam, like the others, is calculated with a crest width of 20 feet slopes of 1 on 1 and 1 on 4.

Table showing approximate estimates of size, cost, and effect of dams on the Middle Fork, above Cañon Creek.

Number.	Height.	Contents.	Cost per cubic yard.	Cost.	Total cost.	Volume stored.	Cost per cubic yard, stored.
	Feet.	*Cubic yards.*				*Cubic yards.*	
1	100	148,852	$0 50	$74,426 00 7,442 60	$81,868 60	3,400,000	.024
2	50	57,700	60	34,620 00 3,462 00	38,082 00	10,000,000	.0038
Total	150	206,552	....	....	119,950 60	13,400,000	.0089

The estimate for storage capacity is rough, the cañon has an average width of from 125 to 150 feet, sides slope at angles of 30 to 35 degrees, and a grade of about 45 feet per mile; the stored material is estimated to take a slope of 18 or 19 feet per mile.

The cañon above is clean of débris of moment, the section below Oregon Bar being the only portion of this river filled much at present.

The mines discharging material into the Middle Fork above this site are Todd's Valley, Forest Hill, Byrd's Valley, Michigan Bluffs, and the Dardanelles, on the north side; and Volcanoville, Mount Gregory, Rubicon, Mount Hope, and Ross on the south side. Of this latter series, Mount Hope and Ross have not been worked for four years, and the others are not extensive. The lateness of the season did not permit of a visit to these mines, and as there was no water returns from El Dorado County it is not possible to make more than a comparative estimate of the amount of material entering this stream. Above this dam it cannot, however, be more than 2,000,000 cubic yards per season. The first dam will store the first season's material with ample allowance for settlement and a lighter grade than 18 or 19 feet per mile. It is thought best to raise the dam some 50 feet the next season, for by thus moving a larger quantity of rock it can be more cheaply done, although greater storage will be provided than is needed for that season.

It has been mentioned before that this dam is above Cañon Creek, and should storage be attempted upon this stream it will be found very costly, probably in excess of the annual profits of the mines upon that stream. Cañon Creek rises northeast of Georgetown and drains some 18 or 20 square miles. The mines upon it are principally seam diggings at Georgia Slide and Lincoln Hill, with one or two other places of slight moment.

The area available for storage is a short reach of the creek bed some 1,056,000 square feet in area which is filled and graded with slaty débris. It is proposed to rerun this material by cutting down the creek bed below. The value of the property is estimated by those interested at $30,000, but the facts that no purchasers have come forward, and no steps taken to utilize the property, do not warrant so high a value. The grade through this reach is about 1 foot per 100, and as the volume of flood water is small the stored material would stand upon about a parallel grade. A crib dam could be built at the lower end of the reservoir; this dam need not be over 10 feet high with a crest length of 100 feet, cubic contents 1,300 yards. The area given above would store about 900,000 cubic yards; and as material enters this stream at the rate of about 60,000 or 70,000 yards per year, the storage provided by a dam 10 feet high would last for at least ten years. It would then be necessary to cover the dam with stone and raise it somewhat. Timber is abundant, and the haul need not exceed one-fourth mile. Stone is not abundant, but can be found within one-half mile below. The estimate for the cost of a dam here is $2.50 per cubic yard for crib work, or $3,250; to which may be added contingencies, 20 per cent., $650, and $30,000 for the condemnation of the reservoir site; total, $33,900; the cost of storing one yard of the material will be about $.0377, or nearly 4 cents per yard, an amount but slightly under the cost of mining by the hydraulic process. The amount of material escaping from Cañon Creek in its present condition is small, but should the project of reworking these tailings be put in operation a very large amount may be expected. This material will be fine and friable and will form good soil, as it is the same as has been mentioned as coming from the South Fork of American River.

THE SOUTH FORK.

The South Fork has a drainage area about equivalent to that of the other two, the basin of the American being about evenly divided by the three forks. Its low-water discharge is much in excess of what it would naturally be on account of the storage water discharged in the dry season from the California Water Company's Reservoirs on the north side of its basin, and from the El Dorado Deep Gravel and Water Company's Reservoirs on the other; and with this increase is about equal to that of either of the other forks. The cañon of the South Fork was examined on foot from Chile Bar Bridge opposite Placerville to the mouth, at Mormon Island, a distance of about 45 miles. At the upper of these points the cañon is about one-fourth mile deep, with sides of slate. The bottom is comparatively clean, and the cañon presents no features of an unusual or unnatural appearance, except the signs of having carried a great deal of sand and finer material. At various points quite extensive mining operations have been carried on, principally at Salmon Falls, Colonna and Mormon Island; but these points are now noted more for their fruit than for their production of gold; the whole river-bed at localities has been mined, and is now leased to Chinese to such an extent as to show more of this race engaged in mining operations than of any other. The extent and frequency of these claims would be a bar to storage.

The grades vary from about 40 feet in the upper reaches to 15 feet or even less per mile in the lower.

Hydraulics and other mining in the basin of the South Fork.—The only extensive hydraulic mining in the basin of the South Fork is upon Weber Creek, a tributary on the south side, draining the country around Placerville; there were three points at which the hydraulic process was used during the examination—Smith's Flat, and at two points on Coon Hollow; at these places the mining is carried on so as to move between 200,000 and 300,000 yards per year.

The gravel deposit upon which these mines are situated is very extensive, extending from in the neighborhood of Placerville to above Sportsman's Hall, a distance of some 14 miles.

This deposit is lava-capped, and cannot be worked by the hydraulic process. Such portions of the edges as paid have been worked. There is a mile or more of old mines which have been worked back to this lava cap and abandoned. It may or may not pay to work this deposit of gravel by the drifting process, but hydraulic mining has very nearly reached its limit. At and around the headwaters of Weber Creek there are small mines worked or prospected during the winter season, but the amount of storable material handled is insignificant.

On Greenwood Creek there is a limited amount of "seam diggings" worked by the hydraulic process, but only the fine material escapes from these mines, 80 per cent. remaining on the dumps. This fine material, once reaching the South Fork, is carried entirely out of the river and into the Sacramento. It, with the bulk of the material moved in the basin of the South Fork, is too fine to be stored in the cañons with economy. On Onion, Beer, and Silver creeks there were reported gulch mines, and limited deposits of gravel from 6 to 10 feet deep, but these were of such slight extent, and worked only during the wet season, by sluicing principally, that they were not specially examined.

Upon Dutch, Johntown, Irish, Manhattan, and Empire creeks there have been mining operations of considerable extent by the sluicing process mainly, but there was no hydraulic mining going on, and nothing to warrant the opinion that any would be undertaken. There were several gulches mined, and a few mills of considerable value, moving an insignificant quantity of fine material.

It was not possible in the limited time to get a definite idea of the number of quartz and cement mills at work in the basin of the South Fork. Those around Placerville were discharging a small amount of fine material into tributaries of Weber Creek, but this amount is so small in comparison with that moved by other processes that it deserves no attention, and its effect upon navigable steamers is evidently inappreciable. This class of mining is generally prosperous, and likely to increase in extent and products.

Storage in the South Fork.—There are strong and apparent reasons why storage should not be attempted in the cañon of the South Fork.

1. The material entering is too fine to be stored upon steep grades.
2. There are no deposits in the bed of the stream which are likely to be swept out.
3. The hydraulic mines in its basin do not present a value sufficient to warrant the expenditure.
4. The material is of a different nature from that on streams north, and is very valuable to warp up swamp lands below.

Several sites for dams were examined, but it is not considered necessary to mention them further than to state that, although sites for dams are available, the storage above is very limited, and would be costly in most instances on account of property in the reservoir space.

The fineness of the material is shown by the absence of a graded deposit back of the Natoma Company's dam. This dam is about a mile above Salmon Falls, and diverts 3,000 inches of water into the Natoma Ditch. It is about 300 feet long and 8 feet high, and was built in 1868. The material used in its construction is basalt coped with timber. Above the dam is a standing pool some one-half to three-fourths of a mile long. There must be a slight deposit in this space during low-water, but floods sweep all material over the crest of the dam. This is a state of affairs nowhere seen on any of the streams farther north which carry coarse material. Such dams on the North Fork of American, on Bear or any of the forks of Yuba River, are filled to the crest and graded above with débris.

Should the coarser material from the North and Middle forks be stored by dams above the North Fork bridge and Cañon Creek, the finer from these sources and from the South Fork can be advantageously used in warping up low swamp lands, as outlined in a report submitted last January, regarding the lower portion or the American River.

Two of the tributaries of the South Fork merit attention regarding storage: these are Weber and Greenwood creeks; and although storage upon each will be costly, it may be advisable to stop some of the coarsest material entering these streams; of the two, Weber Creek is the most important. This stream rises some 12 miles east of Placerville and empties about 4½ miles above Salmon Falls; it drains about 70 square miles; it was examined for some 10 miles. Storage is available at two points—just below Cold Spring, 3 miles below Placerville, and near Anderson's Bridge, some 3 miles lower down. The reservoir space in the first is too costly, being covered with placer and creek claims, and orchards, gardens, and farming lands; the site for a dam to utilize this space is not good, and coupled with the cost of the storage area stops its further consideration. At the lower point a space some 1,200 feet long, with an average width of about 300 feet and sides sloping at angles of 25 degrees, is available. The selection for a dam is estimated with a width of 85 feet, sides slope at angles of 25 and 45 degrees; an overflow in solid rock can be constructed on the right bank. A dam here 40 feet high is estimated to contain 26,400 cubic yards and to retain 460,000 cubic yards. As material is available close at hand and the site very accessible, it is estimated that this dam need not cost over $1 per cubic yard (covering contingencies) or $26,400, giving a cost of $0.057 per yard of stored material.

It has been previously estimated that material enters Weber Creek at the rate of from 200,000 to 300,000 yards per year; the amount of storable material reaching this reservoir is not likely to be in excess of the smaller figure; the storage provided will then be likely to last for two or three seasons, but is extremely costly, about equaling the average cost of hydraulic mining.

Greenwood Creek rises near Georgetown, and draining some 20 square miles, empties a few miles below Coloma. Mining upon it is limited to "seam diggings," in which the hydraulic process is applied in the majority of instances, and to gulch mining, which is practiced during wet months principally.

Most of the mines in its basin were visited and a general knowledge of their condition gotten. It is estimated that from the seam diggings about 72,000 cubic yards per season are moved, of which 80 per cent. remains on the dumps, leaving 14,400 cubic yards escaping To this may be added an equal amount as mined during the rainy season in gulches and natural wash, or a total of 28,800 cubic yards to be provided for annually.

Storage area is available just below the village of Greenwood, but is also limited by that village. Property in its limits has already been much damaged by débris, but the owners being either interested in the mines, or dependent upon their patronage, have taken no steps to stop the discharge of débris. The storage is as follows: About 1 mile below Greenwood there is a flat one fourth mile long and about 300 yards wide, or an area of 18.1 acres. There are two small tributaries entering Greenwood Creek in this flat, upon each of which there is a little placer mining. This flat is owned and partly mined out. Ten or twelve Chinese cabins and two dwelling-houses are within and below the storage plane. At the lower end of this space is a cañon 35 feet wide with rocky sides sloping at angles of 22 and 38 degrees. A dam here 25 feet high is estimated to contain 4,950 cubic yards, and to store 293,000 cubic yards.

The costs are estimated as follows:

18.1 acres, at $100 per acre	$1,810 00
4,950 cubic yards stone work, at $1.25	6,187 50
Contingencies, &c., 20 per cent	1,599 50
Total	9,597 00

This reservoir will furnish storage for several years, but at a cost of a little over 3 cents per yard.

The other tributaries, Dutch, Silver, Beer, Onion, Manhattan, and Empire, have no extensive mines upon them; none certainly that would warrant an expenditure sufficient to provide storage for the fine material moved during winter months, when the streams are large enough to carry out all mined material.

SUMMARY.

For the American the following facts were found:

The North Fork is much filled in that portion above the junction of the Middle Fork; it is the recipient of from 2,500,000 to 3,000,000 cubic yards of débris yearly. The cheapest and most available storage is secured by the erection of a dam about 1 mile above the North Fork Bridge.

The Middle Fork is less filled than the North Fork, and receives yearly about 2,000,000 to 2,250,000 cubic yards of débris. Storage in its lower reaches is not practicable on account of valuable mines in and near the bed of the river. Storage is available by the erection of a dam about 2 miles above the mouth of Cañon Creek.

The South Fork and its tributaries are slightly filled, the débris entering them is very fine, and too easily transported to admit of economical mountain storage, as well as being small in amount. No deep gravel deposits are likely to be worked for many years longer, and those that are worked are not of sufficient value to justify the expenditure of any large sum for the erection of storage dams.

The limited storage upon the tributaries is too costly for present consideration, and the amount of injury done to navigable streams by the small amount of detritus moved by the mines upon them is insignificant when compared with that from the extensive operations upon rivers farther north.

I have the honor to remain, colonel, very respectfully,

MARSDEN MANSON,
Assistant Engineer.

Col. G. H. MENDELL,
Corps of Engineers, U. S. A.

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3. REPORTS OF MR. MARSDEN MANSON, ASSISTANT ENGINEER.

YUBA RIVER BRUSH DAM.

MARYSVILLE, CAL., *August* 7, 1881.

SIR: Agreeably to instructions from you of recent date, I have made an examination of the Yuba River Dam. The accompanying profile of the crest gives the various breaks and depressions occurring. The measurements were made from a point on the north bank in the prolongation of the crest of the dam at which a post was planted by the State engineer department. The portion of the profile made in *red* shows the breach occurring in the covered wing-levee connecting the dam with the north bank. The portion in *black* is the profile of the bed and bank in the crest line prolonged.

BREAK IN WING LEVEE.

Four hundred and forty feet of the wing levee on the north bank and adjoining dam were torn out; in this breach 190 feet of good brush foundation remained. A small channel exists in the right end of this breach. This channel 49 feet wide, soundings through water, mud, and sand to hard sand, were taken as follows:

Ten feet from right bank, 1.5 feet.
Center, 2.0 feet.
Ten feet from left bank, 3.0 feet.

BREAKS AND INJURIES TO THE DAM.

From station 12 + 80 to 14 + 50 there was a sink occurring in the early part of the winter of 1880–'81. This was partly repaired and protected by a dam of sand bags above. The dam, apron, and mattress were forced down stream about 20 feet, in the center of the sink; no portion of the structure was torn out, and the foundation for repairing is firm and good. The mattress below is firmly imbedded in the sand, as was determined by driving rods into it.

From station 14 + 50 to station 64 + 71 the dam apron and matress are practically intact, except the sinking shown in the profile; and that from station 43 to 48 + 50 the mattress was subjected to the action of heavy drift, and is somewhat torn on its upper face; it however needs but little if any repairing.

From station 64 + 71 to station 71 there is a break of 629 feet in length. The ends show that the dam was torn asunder. A few sticks of the timber are left imbedded in the sand about 200 feet from the south end of the break.

The following soundings were taken along the line of this break, the rod passed through water and shifting sand to packed sand:

At station 65, 1.5 feet; at station 65 + 50, 1.0 feet: at station 66, 2.0 feet; at station 66 + 50, 1.2 feet; at station 67, 0.9 feet; at station 67 + 50, 3.0 feet; at station 68, 0.5 feet; at station 68 + 50, 2.0 feet; at station 69, 0.5 feet; at station 69 + 50, 1.0 feet; at station 70, 4.0 feet; at station 70 + 50, 2.0 feet; at station 71, 3.5 feet. The bottom is firmer than in the channel of the river in 1880 during June and July, and in about the corresponding place.

The whole volume of the river passes through this break, except the small quantity passing through the break near the north bank, and used for irrigation.

From station 71 + 50 to station 80 + 52 the dam, apron, and mattress are intact, except the sinking or compression shown on the profile.

From 80 + 52 to 83 + 50 there is a break 298 feet long. The ends show that the dam was torn asunder. A small quantity of clear, cold seepage water was flowing through the north end of this break.

The following soundings were taken; the rod passed through water, mud, and sand, to packed sand:

At station 82 + 05, 3.0 feet; at station 82 + 50, 2.0 feet; at station 82 + 75, 2.5 feet; at station 82 + 90, 2.0 feet; at station 83, 2.0 feet; at station 83 + 43, 3.0 feet. From station 89 + 90 to 90 + 95 the dam sunk more than usual; apron sound; 40 feet of mattress damaged; easily repaired by new mattress on top of the old.

From station 91 + 67 to 92 + 10 small sink; dam and apron firm; 43 feet of the mattress badly damaged, but easily repaired by new mattress on top of the remains of the old.

The wing levee on the south bank is not injured, nor is the planking levee up the south bank.

(The general condition of the levees below the dam was the subject of a report by me to the State engineer in April last.)

The condition of the dam, other than the three large breaks, is shown in the profile. It was constructed with a crest elevation of 113.0 feet, with an addition of 15 per cent. (15 per cent of its total height) to allow for compression and settling. The foundation for any future repairs upon the settled portion is very good.

RÉSUMÉ.

Serious damages to the Yuba River Dam.—From station 6 + 30 back along wing levee, 440 feet of dam and wing levee broken.

From station 64 + 71 to station 71 + 10, 639 feet of dam torn out.

From station 80 + 52 to station 82 + 50, 298 feet of dam torn out.

Total breaks, 1,377 feet.

Injuries and breaks in mattress (other than at breaks in dam).

From station 89 + 90 to 90 + 95, small sink in dam, 60 feet mattress torn out.

From station 91 + 67 to 92 + 10, small sink in dam, 42 feet mattress torn out.

From station 92 + 35 to 93 + 37, small sink in dam, 102 feet mattress torn out.

Total mattress badly damaged and torn out, 205 feet.

From 43 to 48 + 50, 550 feet of mattress slightly damaged.

It is respectfully suggested that in case this dam be repaired that spurs be built, projecting above and below the dam, so as to prevent lateral currents along the face and mattress.

Very respectfully,

MARSDEN MANSON,
Assistant Engineer.

Colonel G. H. MENDELL,
Corps of Engineers, U. S. A.

ESTIMATE FOR REPAIRING BRUSH DAM ON YUBA RIVER.

The following estimate is appended to the report on the Yuba River Brush Dam.

It is by no means certain that the cost of repairing this work may not largely exceed the estimate, as since the examination from 600 to 1,000 feet of this structure has been reported burnt, and the floods of this winter may, in the poor condition of the dam, inflict still further damage.

The estimate covers the repairs found necessary in the examination of August, 1881;

and the stone required to raise the crest 4 feet over the dam, and 2 feet over the repairing crib work.

The slopes are estimated at 1 on 1 and 1 on 2; crest width, 6 feet.

In the case of sinks in the dam where only depressions have occurred, it is proposed to raise them to an elevation of 113 feet, with brush and tree work of the same general nature as the structure. Where the dam and wing levee have been torn asunder, it is proposed to repair with crib work; raising this 3 feet above the crest of the dam, and entirely above the reach of floods.

It is thought best to make the estimate for tree work, in number of trees required, and to price each tree rather than by the cubic yard; as these trees will have to be hauled from 1¼ to 3 miles, and to deliver them, will be one of the principal, if not the greatest cost of repairing.

Only the sum total of repairs to the sinks is given, as to mention each would only encumber the report.

To raise dam to even grade, 10,000 trees will be requird at $1	$10,000
For excavating, placing, handling, and covering, at 80 cents each	8,000
	18,000

MATTRESS WORK.

	Square yards.
1. Repairing breaks	3,690
2. Repairing damaged mattress	684
	4,374
4,374 square yards mattress, at $1	$4,374

CRIB AND BRUSH WORK IN BREAKS.

Break in north wing levee 440 feet long; 14 to 16 feet high:

	Cubic yards.
Brush subfoundation	1,500
Crib work	7,818
	9,218
1,500 cubic yards subfoundation, at $1.12½	$1,687 50
7,820 cubic yards crib work, at $1.50	11,740 00
	13,427 50

Break in dam from 64 + 50 to 71; 650 feet of crib work 9 feet high:

780 cubic yards brush subfoundation, at $1.12½	$877 50
4,650 cubic yards crib work, at $1.75	8,137 50
	9,015 00

Break in dam from 80 + 50 to 83 + 50; 300 feet crib work 13 feet high:

500 cubic yards brush subfoundation, at $1.12½	$562 50
4,300 cubic yards crib work, at $1.75	7,525 00
	8,087 50

90,000 sacks filled and placed, at 15 cents	$13,500 00
Total cost of repairs	66,403 50
Contingencies, 20 per cent	13,280 70
Total first season	79,684 20

To cover this structure, as before mentioned, with stone, it is estimated that it will require:

57,400 cubic yards, at $2	$114,800
Contingencies, 20 per cent	22,960
	137,760

The capacity of the reservoir made by maintaining the crest of this dam at an elevation of 113 feet was estimated by the State engineer at 40,200,000 cubic yards. Such a capacity would only be reached when the river had established a grade parallel to the one existing prior to the construction of the dam.

As the crest was not maintained, the storage secured amounted to 4,851,000 cubic yards, as estimated by the State engineer's department.

Since the maximum storage of 40,000,000 cubic yards will only be reached when the grade is parallel, it follows that the river will then be able to carry as much material past the site of the dam as it does now.

Two-thirds of the estimate above given is a fair estimate of the effective storage of this reservoir.

To raise the crest 4 feet, as proposed, with stone, will create storage for about one season's mining, or from 19,000,000 to 20,000,000 cubic yards, after the exhaustion of which it will be necessary to again raise the crest or erect structures elsewhere.

Very respectfully,

MARSDEN MANSON,
Assistant Engineer.

SAN FRANCISCO, CAL., *January* 20, 1882.

BEAR RIVER BRUSH DAM.

WHEATLAND, YUBA COUNTY, CALIFORNIA,
August 21, 1881.

SIR: Agreeably to instructions, I have made an examination of the Bear River Dam, carrying a line of levels over its crest to ascertain the position and extent of all breaks and sinks. I have also rerun the sections of the reservoir space above the dam. Regarding the injuries to the dam, they are best made known by an inspection of the profile submitted. The following additional notes are also added:

BREAKS.

From station 5 + 90 to 10 + 10 is a clear break 420 feet long. The dam has been torn asunder here, but a very firm and substantial foundation was touched 4 feet below the surface of the sand. There was too much water to uncover this and examine it, but it was touched *only* along the line of the mattress and dam, and could not be found above nor below.

From 47 + 04 to 48 + 03, clear break 99 feet long, dam torn out; solid foundation found in part of the break only. (See profile.)

Total breaks, 519 feet.

SINKS AND DAMAGES TO MATTRESS OTHER THAN AT BREAKS.

From 14 *to* 14 + 66.—Sink; foundation solid; 20 feet of mattress damaged; 47 feet torn out; 67 feet needed to replace.

From 17 + 50 *to* 18.—Sink; foundation good; 40 feet of mattress damaged; easily repaired by new mattress on top of old.

From 25 + 40 *to* 26 + 70.—Sinks. The apron here is raised up as if the upper ends of the timbers composing it sunk very much. There was a large volume of water pouring over in this portion of the dam, and the foundation must be solid and packed; 135 feet of mattress torn out and badly damaged; best repaired by new mattress over the entire length and on top of the old.

From 49 + 60 *to* 49 + 95.—Deep sink; foundation good. The mattress, if left, has sunk some 3 feet; this is the case back to the break at 48 + 04; as this was not uncovered on account of the seepage water, it is estimated that 190 feet of new mattress will be required here; later in the season, or during repair, this will be easily ascertained.

From 51 + 23 *to* 51 + 56. Sink. Foundation good; 50 feet of mattress torn out.

From 52 + 80 *to* 61 + 10. There were a series of sinks of various sizes and depths. This was the last portion of the dam completed (except the channel), and much fine brush was used in the construction and in the partial repairs made during the early part of the winter.

Double layers of sand-bags were placed along the upper face, and in places extended above the crest, as shown at the junction of the dam and levee. The total length of mattress damaged here is 300 feet; that left is sound and sprouting well. The foundation is fair.

TOTAL DAMAGES TO MATTRESS (OTHER THAN AT BREAKS).

From 14 to 14 + 66; sink; 67 feet of mattress damaged or torn out.
From 17 + 50 to 18; sink; 40 feet of mattress damaged or torn out.
From 25 + 40 to 26 + 70; sink; 135 feet of mattress damaged or torn out.
From 48 + 04 to 49 + 95; sink; 190 feet of mattress, probably damaged.

From 52 + 80 to 61 + 10; sink; 300 feet of mattress, damaged and torn out. Total, 732 feet of mattress.

The wing levee on the south bank is firm and intact.

GENERAL CONDITION OF THE DAM.

The whole structure is more dry and open than the Yuba River Dam. The sand has been washed out of the structure by the percolation of water through the sand-bags on the face, and it is too light to stand a flood in its present condition. This is due to the seasoning and drying of much of the timber.

The sand-bags frequently cave in when one is walking over the dam, and the sand runs down into the interstices beneath. In repairing, the whole dam should be carefully examined for these hollow places, and the bags removed, the spaces filled and dumped with dry sand, with a compact layer of fine sediment on top, with a new face of sand bags.

The willows in many places have sprouted, and have a close growth of shoots from 3 to 6 feet long; cottonwood has also sprouted in many places, but the alder was invariably dead.

The most vigorous growth is in the long timbers composing the crest, and reaching back up the face of the dam.

The body of the dam, constructed principally of fine brush, is dead and dry.

The apron is but little sprouted; but the mattress is about half covered with small young shoots. The dam could be easily repaired, the principal difficulty and expense being in getting timber, which will have to be hauled at least 2 or 3 miles.

I have the honor to remain, colonel, very respectfully,

MARSDEN MANSON,
Assistant Engineer.

Col. G. H. MENDELL,
Corps of Engineers, U. S. A.

ESTIMATE FOR REPAIRING BRUSH DAM, ON BEAR RIVER.

This dam was examined in August, 1880, and the sections above rerun.

The following estimates are made regarding the storage afforded so far, and the cost of repairing and covering with stone.

The data regarding the sections of the reservoir were sent to Mr. C. E. Grunsky, assistant State engineer, and by him the following calculations were made, from the former data in the office of the State engineer.

Table showing amount of material stored above Brush Dam, on Bear River, from October, 1880, to August, 1881.

Number of section.	Increase of sectional area.	Deposit between sections.	Remarks.
	Square feet.	*Cubic yards.*	
1	10, 008	370, 700	From dam to section 1.
2	2, 232	226, 700	1 to 2.
3	3, 744	105, 700	2 to 3.
4	3, 096	130, 500	3 to 4.
5	1, 728	90, 200	4 to 5.
6	144	34, 700	5 to 6.
7	0	2, 500	6 to 7.
8			No storage.
9			
Total		961, 000	

For repairs to the dam as found in August, 1881, the following estimate is submitted: The number of trees necessary to raise the sinks is given, rather than the number cubic yards, as in the case of the Yuba Dam; the brush and trees will have to be hauled some 2 to 3 miles. It is estimated to raise this dam to an elevation of 124.5 feet, and the breaks 3 feet higher with crib-work. The estimate is for covering with stone, to raise the crest 4 feet, and to give the lower face a slope of one-half. The crib-work is correspondingly raised and covered 3 feet.

REPAIRS TO BREAKS.

6,220 cubic yards crib-work, at $1.25	$7,775 00
880 cubic yards subfoundation, at $1	880 00
11,175 trees, delivered, placed, and covered, at $1.75	19,556 25
60,000 sacks, filled and placed, at 15 cents	9,000 00
4,170 square yards brush mattress, at $1	4,170 00
Contingencies, 10 per cent	4,138 12
Total	45,519 37

The storage secured by maintaining this dam at an elevation of 124.5 feet was estimated by the State engineer department at 8,950,000 cubic yards.

The same reasons why this storage would not be effective as were mentioned for the Yuba Dam apply here, and the effective storage is probably not over 5,000,000 to 5,500,000 cubic yards, or about storage for one season's detritus.

To cover this dam with stone will be costly, for none exists nearer than from 1½ to 2 miles. To raise the crest 4 feet, and cover the lower slope, will require—

For covering the crib-work	cubic yards..	4,000
For covering the dam	do	28,500
Total	do	32,500

32,500 cubic yards stone, at $2	$65,000 00
Contingencies, repairs, &c	10,000 00
Total	75,000 00

This will about provide storage for the second season's debris, or 5,000,000 to 5,250,000 cubic yards.

Very respectfully,

MARSDON MANSON,
Assistant Engineer.

JANUARY 23, 1882.

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4. APPROXIMATE ESTIMATE OF MINING GROUND WORKABLE BY THE HYDRAULIC PROCESS IN THE FOLLOWING DISTRICTS, DRAINING INTO BEAR RIVER, CALIFORNIA, BY ANDREW LARSON, NOVEMBER, 1881.

	Cubic yards.
Liberty Hill District:	
Twenty acres 17 yards deep	1,645,600
65 per cent. bowlders and cobbles.	
35 per cent. small gravel, with some sand.	
Altitude of channel, 3,425 feet.	
Fall into cañon and Bear River, 475 feet.	
Lowell Hill:	
Contains no hydraulic ground.	
Remington Hill District:	
Excelsior Point, five acres, 20 yards deep	484,000
60 per cent. bowlder, cobbles, and small gravel.	
40 per cent. fine gravel and sand.	
Altitude of channel, 4,025 feet.	
Fall into Steep Hollow, 300 feet.	
Pleasant Hill:	
One acre 12 yards deep	58,080
80 per cent. gravel and cobble.	
20 per cent. fine gravel and sand.	
Altitude, 3,940 feet.	
Fall into Steep Hollow, 400 feet.	
Little York District—Manzanita Hill:	
Forty acres 2½ yards deep	484,000
Christmas Hill, twenty-five acres 5 yards deep	605,000
60 per cent. rock and gravel.	
40 per cent. sand and *débris*.	
Altitude, 3,100 feet.	
Fall into Bear River and Steep Hollow, 350 feet.	

	Cubic yards.
You Bet District:	
Eighty acres 25 feet deep	9,680 000
70 per cent. cobbles and rocky material.	
30 per cent. small gravel with sand.	
Altitude, 2,720 feet.	
Fall into Wilcox Ravine and Steep Hollow from 12 to 20 feet.	
Red Dog District:	
Forty acres 25 yards deep	4,840,000
80 per cent. rocky material and cobbles.	
20 per cent. small gravel with sand.	
Altitude, 2,780 feet.	
Small dump by extending flume into cañon and Green Horn.	
Hunt's Hill District:	
Twenty-five acres 20 yards deep	2,420,000
70 per cent. cobbles and rocky material.	
30 per cent. small gravel with sand.	
Altitude of channel, 2,750 feet.	
Fall 12 feet into Green Horn.	
Quaker Hill District:	
One hundred and twenty acres 28 yards deep	16,262,400
60 per cent. gravel.	
40 per cent. sand and clay.	
Altitude of flume, 2,960 feet.	
Dump or outlet level with Green Horn.	
Hydraulic workings 200 feet above bottom.	
Sailor Flat District:	
Forty acres 25 yards deep	4,840,000
50 per cent. bowlders and rock.	
50 per cent. small gravel with sand.	
Altitude, 3,250 feet.	
Dutch Flat District:	
Amount remaining to be mined	8,500,000
75 per cent. of which is heavy material.	
Total amount of hydraulic ground	49,819,080

REMARKS.

Lowell Hill District contains no gravel which can be worked by hydraulic. The gravel bank where it was cut into and exposed in the edges shows a thin deposit of bowlders and gravel, from 10 to 15 feet thick, which is overlaid by clay, volcanic earth, and lava rocks, some of them very hard; all of this top stratus is not auriferous.

Northwest from Lowell Hill, across Steep Hollow is—

Melburn Hill.—This place has a name, but no mining ground and no one living there when I was there. Less than one acre of ground has been worked off, and there is very little left. It appears to be a very small remnant of ground left in the edge of the hill, which was once the extreme western edge of the Remington and Lowell channel, before it was cut off by the present stream of Steep Hollow.

Remington Hill.—On the point of this was a gravel deposit about thirty acres in extent, which has been worked off clean to bed rock; no more hydraulic ground remains in this district, as the channel passes northeastward under the side of a high lava ridge, so this channel can only be worked by drifting.

Pleasant Hill was a small isolated hill, seven acres worked off and but little left to be mined.

Excelsior Hill.—Covered with a high lava cap, back of the point, and cannot be worked by hydraulic.

You Bet District.—At this district most all the top gravel is worked off, from one side to the other, on to the shallow bed rock, as far as it would pay. There yet remains considerable ground over the deep part of the channel, from 1 to 200 feet in depth; the lower 100 feet of this gravel is very hard and must be blasted extensively to be mined in any shape, and the dump or outfall into Wilcox Ravine being now very small, from 12 to 15 feet, so that the lower 50 to 100 feet of this channel cannot be worked by hydraulic process. At the northwestern part of this channel at Red Dog, the Arkansas and Missouri cañons are full of tailings up to the grade of the ancient channel.

No channel exists to the east and northeast of the town of Red Dog, as laid down on Professor Whitney's map.

Hunt's Hill may be worked to bed-rock as stated in my report, but it is very hard, cemented to the depth of 40 or 50 feet on the bottom.

Quaker Hill is the same channel as Hunt's Hill, extending north towards the South Yuba.

In the principal hydraulic mine, which has been running for several years, the dump or outfall into Green Horn is zero; that is to say, the sluices from the mine and tailings in the creek are even, level.

The head of the flume or sluices in the mine or pit is near 200 feet above the bed-rock.

South from the town of Quaker Hill this channel is capped with lava on the west side from 50 to 150 feet. From the town northward this channel is covered with a very high lava ridge, so that only a small portion along the eastern side has been accessible to hydraulic working, and the most of that has already been worked off, so that only a small proportion of Quaker Hill Channel can ever be worked by hydraulic process.

Sailor Flat has a gravel deposit which shows a small amount of wash or erosion; the rocks being large and angular, overlaid by a large amount of clay, earth and débris not gold-bearing, so that hydraulic working will be limited to my estimate.

You Bet. A small gravel range exists to the west of You Bet about 2¼ miles, but there is not enough to justify bringing water on to it, as it would be over low ground at a great cost.

Little York and Liberty Hill are small districts limited in amount and not encumbered by lava caps. Dutch Flat, the same.

Nary Red. One mile northeast from Dutch Flat towards Alta the channel is covered with clay and lava rocks and earth that it will not pay to hydraulic.

Approximate estimate of the amount of ground which may be worked or mined by the hydraulic process, into North Fork American River, or its cañon tributaries:

Iowa Hill District:	Cubic yards.
Iowa Hill proper contains forty acres, 33 yards deep....................	6,388,800

With a uniform gravel bank composed principally of quartz and quartzite, 60 per cent. large cobbles and pebbles, 40 per cent. smaller gravel with some sand.

NOTE.—This is the remnant of a gravel channel passing through the hill under the town, and may be worked off clean to the bottom.

Altitude of bed-rock, 2,900 feet; the western side is lava capped and therefore cannot be worked.

Birds Flat:	
And adjacent mines south side Indian Cañon, contains sixty acres, 25 yards deep....................	7,260,000

Sixty per cent. cobbles and pebbles.

Forty per cent. small gravel, sand, and débris.

Altitude 2,940 feet.

NOTE.—This is a wide spread of river formation extending south under a lava cap 300 to 400 feet in depth, which leaves only this remnant to be worked, the front part of this place having been previously worked off into Indian Cañon.

Monona Flat:	
With part of Independent Hill north side of Indian Cañon thirty acres, 28 yards deep....................	4,065,600

Altitude of channel, 2,940 feet; 60 per cent. cobbles, pebbles, and rocky material, 40 per cent. smaller gravel and sand, and lava earth.

NOTE.—The hydraulic working becomes limited here by the lava cap covering Roach and Independent Hill outfall into Indian Cañon.

Roach Hill and part of Independent:	
Twelve acres, 28 yards deep....................	1,626,240

Sixty per cent. cobbles, pebbles, and rocks.

Forty per cent. smaller gravel, with some sand, clay, and lava earth.

Altitude, 2,940 feet without fall into North Fork American.

NOTE.—This ground is a small remnant at the base of lava cap covering Roach Hill, on the northwestern side.

Wisconsin Hill:	
Contains thirty-five acres, 30 yards deep....................	5,082,000

Sixty per cent. cobbles and pebbles, and 40 per cent. small gravel and sand.

NOTE.—The bottom of this hill is very hard cement, and cannot be worked by hydraulic. On the northeast end of this hill the lava cap covers the gravel formation to the depth of 300 or 400 feet, which shuts off the hydraulic working outfall into Shirttail Cañon.

Prospect Hill: Cubic yards.

Near Wisconsin to the southeast.

Three acres, 16 yards deep 232,320

Small gravel and sand.

NOTE.—This gravel is part of the Wisconsin Hill Deposit, which has an altitude of 2,950 feet, with outfall into Shirttail Cañon, and is covered on the east by 300 to 400 feet of lava.

Elizabeth Town:

Near Wisconsin to the west.

Six acres, 10 yards deep 290,400

Sixty per cent. cobbles and gravel; 40 per cent. small gravel, sand and clay.

Altitude, 2,960 feet, with outfall into a branch of Shirttail Cañon.

NOTE.—This gravel deposit belongs to the west side of Wisconsin Hill Channel, extending south, and is covered by a lava cap known as King's Hill, which is from 200 to 300 feet deep, and cannot be worked by hydraulic.

Yankee Jim's district:

Yankee Jim's proper, the channel all worked out clean to bed-rock, Smith's Point to the east.

One acre, 28 yards deep 135,250

Altitude, 3,000 feet, with outfall into Brushy Cañon, a tributary of the Shirttail.

NOTE.—At this place the channel takes a turn southeast under a high lava ridge, which shuts off the hydraulic, and it is now operated by drifting and milling the cemented gravel.

Georgia Hill:

Half a mile southwest.

Three acres, 16 yards deep 232,320

Altitude, 3,000 feet, with outfall into Devil's Cañon, branch of Shirttail; principally small quartz, gravel, with some sand and débris.

NOTE.—This channel extends south towards Todd's Valley and Middle Fork of American, and is covered by a high lava ridge 300 to 400 feet in depth. This lava cap has now shut off nearly all the hydraulic mining on that channel, and it is now operated in places by drifting and milling the cement.

King's Hill:

Southern and north side Shirttail Cañon.

Three acres, 12 yards deep 174,240

Sixty per cent. pebbles and gravel; 40 per cent. smaller gravel with sand and clay.

NOTE.—This is on the extreme end of King's Hill, and hydraulic mining is shut off by the lava cap of that hill.

Altitude, 3,000 feet; outfall in Shirttail Cañon.

Forest Hill, northern part:

One hundred acres, 40 yards deep 19,360,000

Altitude, 3,000 feet, with outfall into Brushey Cañon No. 3, a tributary to Shirttail Cañon.

Sixty per cent. large cobbles, pebbles, and gravel; 40 per cent. smaller gravel, with some sand, with 40 feet earthy lava on top, which is not auriferous.

NOTE.—This part was the most difficult to estimate, because it is all covered with lava, excepting a very small space, and the hydraulic working depends upon how far the lava material keeps soft; when it gets to be rocky or hard, the hydraulic mining is finished.

Grizzly Flat and Sucker Flat:

Between Indian Cañon and Shirttail Cañon, two small mining camps. The gravel is all covered by volcanic lava and cannot be worked by hydraulic.

Gold Run District:

About ninety-five acres, 40 yards deep on the channel 18,480 000

Ten acres, 25 yards deep, top ground on the northwest side 1,210 000

Altitude on channel, 2,970 feet, with outfall into Cañon Creek, and North Fork American.

NOTE.—The formation on this part of the channel consists of heavy bowlders, large cobbles and pebbles, or rocky material 78 per cent.; 22 per cent.

Cubic yards.

smaller gravel with some sand. The top ground on northwest side about 50 per cent. cobbles, pebbles, and gravel; 50 per cent. fine gravel and sandy débris. This channel contains a large amount of hard trap-rock, which has come in from the east side, in the form of slides, and covering more or less of the sides of the channel, that it limits the hydraulic mining to one side, so that they cannot work the full width.

Alta District (Shady Glen):

Fifty acres, 30 yards deep 7,260,000

Altitude, 3,250 feet.

Material composed of quartz.

Sixty per cent. bowlders, cobbles and pebbles; 40 per cent. smaller gravel, sand and clay; outfall in Cañon Creek.

NOTE.—This channel extends from Shady Run to Dutch Flat, and is lava capped, most of the whole distance from 100 to 400 feet in depth, and hence cannot be worked by hydraulic.

Shady Run District:

Three acres, 25 yards in depth 363,000

Fifty per cent. quartz bowlders and gravel and 50 per cent. sand and clay.

Altitude 4,100 feet, with outfall into Blue Cañon.

NOTE.—This gravel formation, except the amount above stated, is shallow, from 30 to 40 feet in depth, and then covered with clay, sand, sandstone, and lava, so that it cannot be worked by hydraulic.

Green Valley:

Down at the river eight acres, 25 yards deep 968,000

Seventy per cent. bowlders, cobbles and rocky material, 30 per cent. smaller gravel, sand, and clay.

NOTE.—This mining is on a remnant of a deposit of the modern river, and consequently very limited in extent. Hundreds of places of this kind have been operated on by hydraulic, but they have either become exhausted or proved failures.

Lost Camp District:

Twenty-six acres, 15 yards deep 1,887,600

Altitude 4,250 feet, with outfall into Blue Cañon on the west and Texas Ravine on the east.

The rocky material all quartz; 60 per cent. cobbles and pebbles, 40 per cent. small gravel, with some sand and clay.

NOTE.—Farther east on this line the channels contain no hydraulic gravel, as they are either carried away or completely covered with lava, and the gravel portions are generally very shallow.

Damascus District:

Three acres, 12 yards deep ....

Sixty per cent. rocky material, 40 per cent. small gravel and sand. This lies under the town and may never be worked.

The balance of the channel lies under 600 feet of lava cap, with outfall into Humbug Cañon on the north and Eldorado Cañon on the south.

Total number of cubic yards 75,190,010

This estimate includes all the gravel which now remains and may be worked by the hydraulic process, with outfall into the North Fork of the American River or its tributaries.

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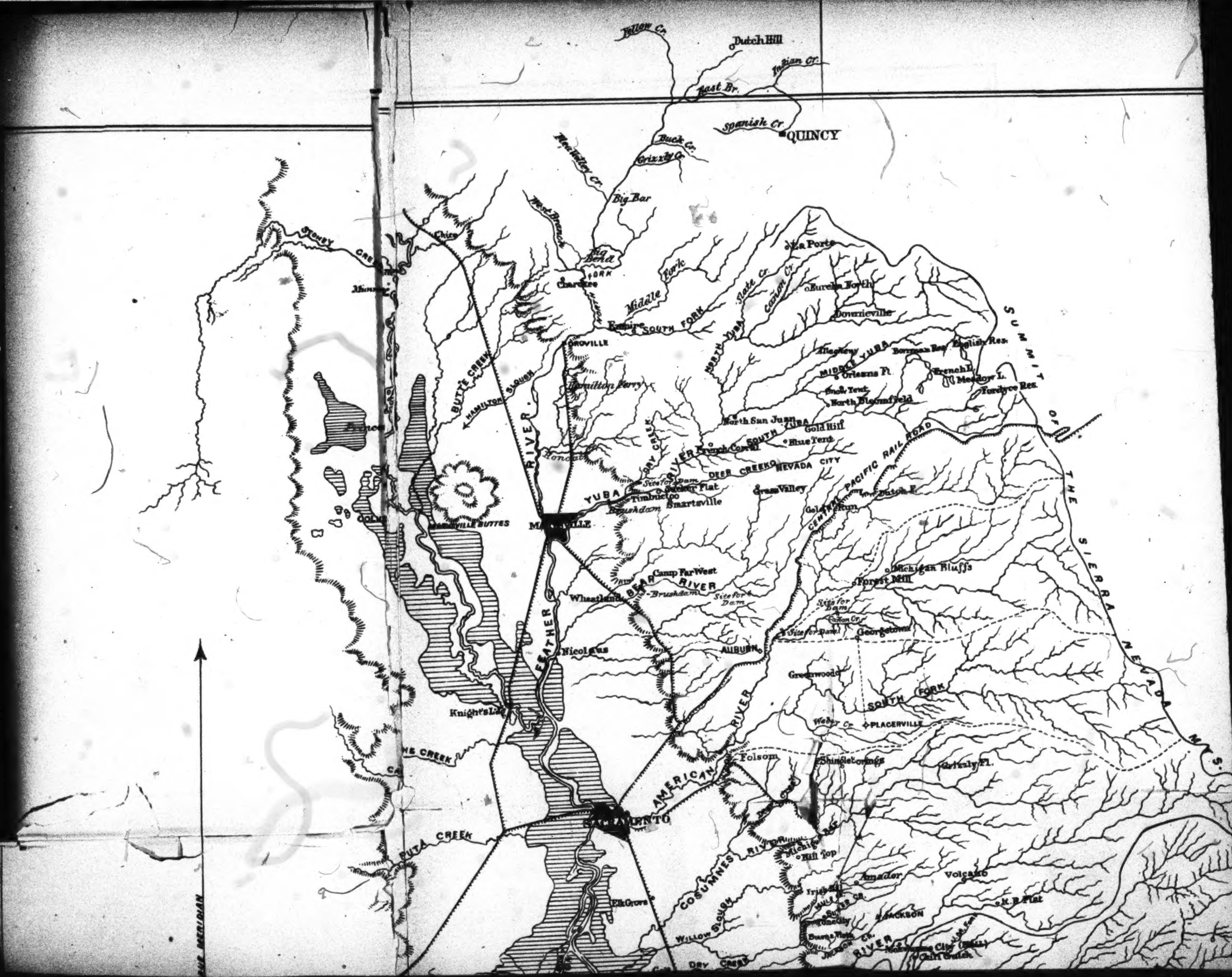
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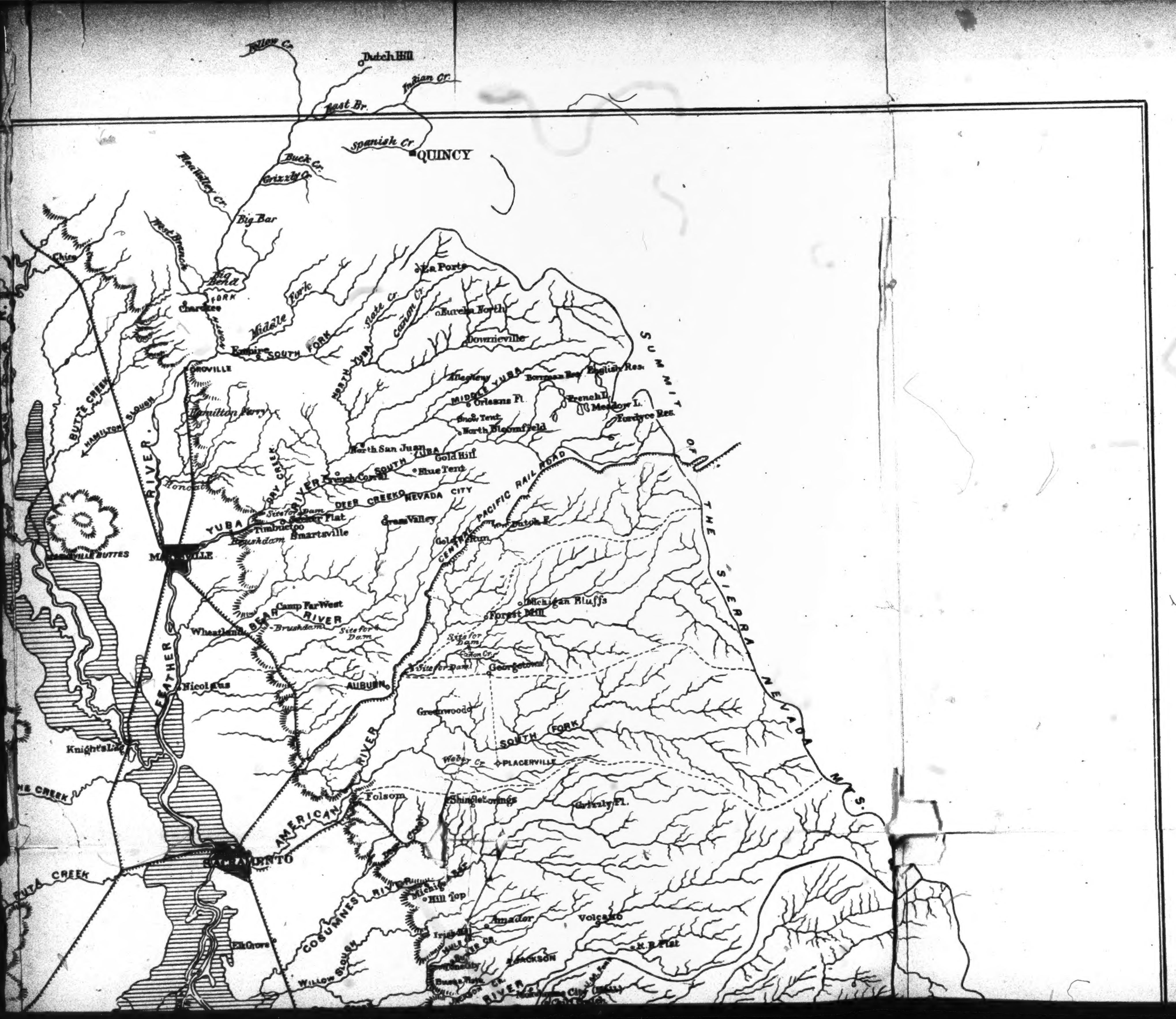
East Br.
Spanish Cr.
QUINCY
Buck Cr.
Grizzly Cr.
Meadow Valley Cr.
West Branch
Big Bar
Chico
Big Bend
Cherokee
FORK
Middle Fork
Empire
SOUTH FORK
La Porte
Slate Cr.
Canon Cr.
Eureka North
Downieville
NORTH YUBA
Allegheny
MIDDLE YUBA
Bowman Res.
English Res.
Orleans Ft.
French L.
Meadow L.
Fordyce Res.
Snow Tent
North Bloomfield
SUMMIT OF THE SIERRA NEVADA MTS.
OROVILLE
BUTTE CREEK
HAMILTON SLOUGH
Hamilton Ferry
North San Juan
SOUTH YUBA
Gold Hill
Blue Tent
French Corral
DRY CREEK
Honcut
RIVER
CENTRAL PACIFIC RAIL ROAD
DEER CREEK
NEVADA CITY
Site for Dam
Sucker Flat
Timbuctoo
Grass Valley
YUBA
Brushdam
Smartsville
MARYSVILLE
MARYSVILLE BUTTES
STONEY CREEK
Colusa
Dutch F.
Gold Run
Michigan Bluffs
Forest Hill
Camp Far West
BEAR RIVER
Brushdam
Site for Dam
Wheatland
Site for Dam
Canon Cr.
Site for Dam
Georgetown
FEATHER
Nicolaus
AUBURN
Greenwood
SOUTH FORK
Weber Cr.
PLACERVILLE
Knight's Landing
CREEK
AMERICAN
RIVER
Folsom
Shingle Springs
Grizzly Fl.
SACRAMENTO
PUTA CREEK
COSUMNES RIVER
Michigan Bar
Hill Top
Amador
Volcano
Elk Grove
Irish Hill
Sutter Cr.
JACKSON
WILLOW SLOUGH
Buena Vista
Jackson Cr.
RIVER
Camp Gulch
DRY CREEK
MERIDIAN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Nelson Valley Cr.
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Big Bend
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Empire
SOUTH FORK
OROVILLE
Slate Cr.
Cañon Cr.
La Porte
Eureka North
Downieville
NORTH YUBA
Allegheny
MIDDLE YUBA
Bowman Res.
English Res.
Orleans Ft.
French L.
Meadow L.
Snow Tent
North Bloomfield
Fordyce Res.
SUMMIT OF THE SIERRA NEVADA MTS.
BUTTE CREEK
HAMILTON SLOUGH
Hamilton Ferry
RIVER
DRY CREEK
North San Juan
SOUTH YUBA
Gold Hill
Blue Tent
French Corral
RIVER
Honcut
DEER CREEK
NEVADA CITY
CENTRAL PACIFIC RAIL ROAD
Site for Dam
Sucker Flat
YUBA
Timbuctoo
Brushdam
Smartsville
Grass Valley
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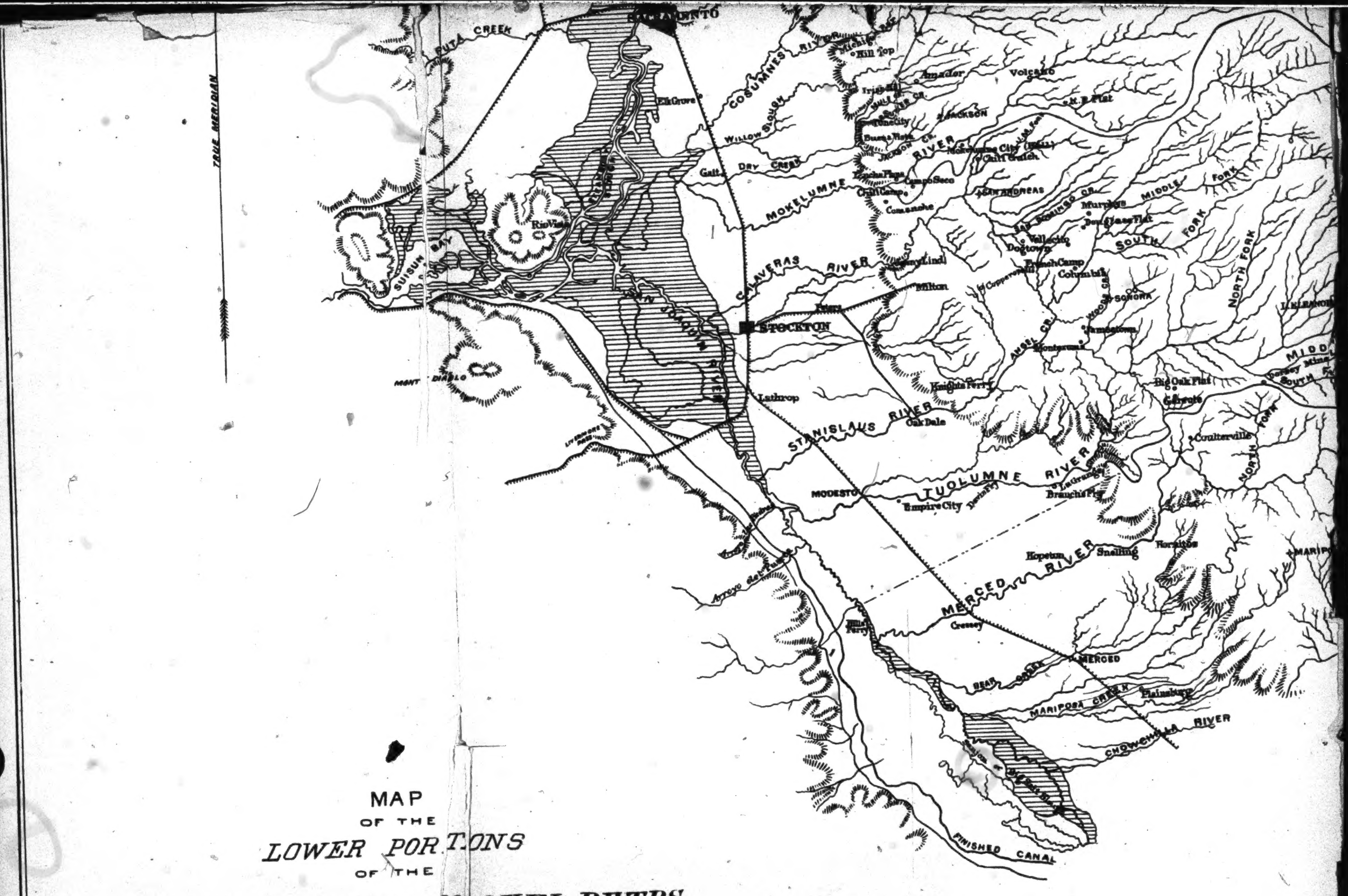
Gold Run
MARYSVILLE BUTTES
MARYSVILLE
Michigan Bluffs
Forest Hill
Camp Far West
BEAR RIVER
Brushdam
Site for Dam
Wheatland
Site for Dam
Cañon Cr.
Site for Dam
Georgetown
FEATHER
Nicolaus
AUBURN
Greenwood
SOUTH FORK
Knight's Ldg.
Weber Cr.
PLACERVILLE
CREEK
Folsom
Shingle Springs
Grizzly Fl.
AMERICAN RIVER
SACRAMENTO
PUTA CREEK
COSUMNES RIVER
Michigan Bar
Hill Top
Amador
Volcano
Irish Hill
SUTTER CR.
H. R. Flat
JACKSON
Elk Grove
WILLOW SLOUGH
Buena Vista
RIVER
Mokelumne City


SACRAMENTO
PUTA CREEK
TRUE MERIDIAN
COSUMNES RIVER
Michigan Bar
Hill Top
Amador
Volcano
Elk Grove
WILLOW SLOUGH
JACKSON
Galt
DRY CREEK
MOKELUMNE RIVER
Mokelumne City
Campo Seco
SAN ANDREAS
Murphys
Comanche
Rio Vista
SUISUN BAY
Vallecito
Dogtown
CALAVERAS RIVER
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Milton
French Camp
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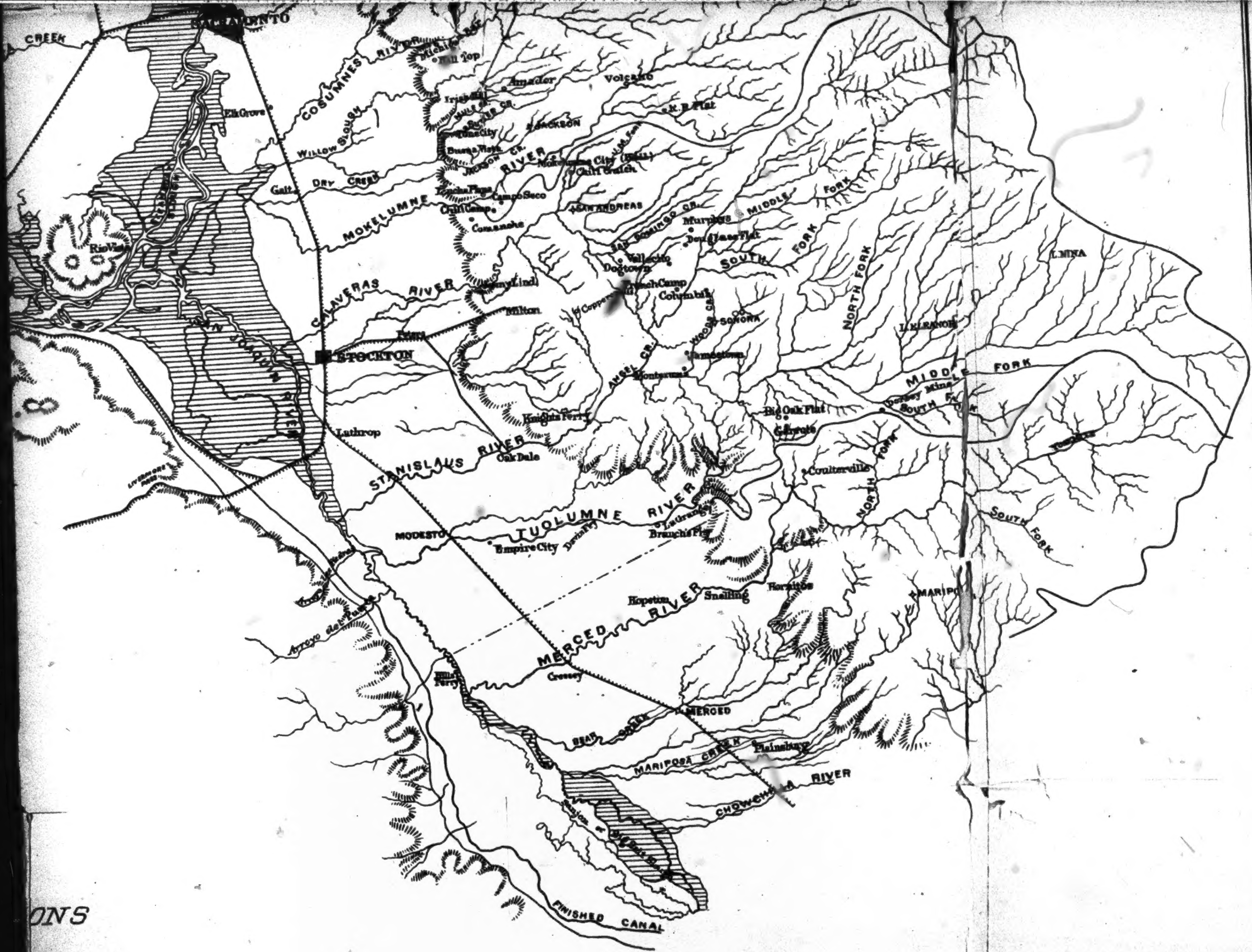
SONORA
SAN JOAQUIN RIVER
STOCKTON
Jamestown
MONT DIABLO
ANGEL CR.
Knights Ferry
Big Oak Flat
Lathrop
STANISLAUS RIVER
Oak Dale
Coulterville
LIVERMORE PASS
TUOLUMNE RIVER
La Grange
MODESTO
Empire City
Hopeton
Snelling
Hornitos
MERCED RIVER
Arroyo del Puerto
Cressey
MERCED
BEAR CREEK
MARIPOSA CREEK
Plainsburg
CHOWCHILLA RIVER
MIDDLE FORK
SOUTH FORK
NORTH FORK
FINISHED CANAL

MAP
OF THE
LOWER PORTIONS
OF THE
SACRAMENTO AND SAN JOAQUIN RIVERS

CALIFORNIA

SHOWING TRIBUTARY STREAMS, DRAINING HYDRAULIC MINING DISTRICTS.

SCALE 12 MILES TO 1 INCH



CREEK
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Hill Top
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Elk Grove
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DRY CREEK
Galt
Buena Vista
JACKSON CR.
MOKELUMNE RIVER
Mokelumne City
Campo Seco
Camanche
San Andreas
Murphys
Douglass Flat
Vallecito
Dogtown
Rio Vista
CALAVERAS RIVER
Jenny Lind
Milton
Copperopolis
French Camp
Columbia
Sonora
Jamestown
STOCKTON
SAN JOAQUIN RIVER
ANGEL CR.
WOODS CR.
Montezuma
SOUTH FORK
MIDDLE FORK
NORTH FORK
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Big Oak Flat
Garrote
Knights Ferry
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Oak Dale
Coulterville
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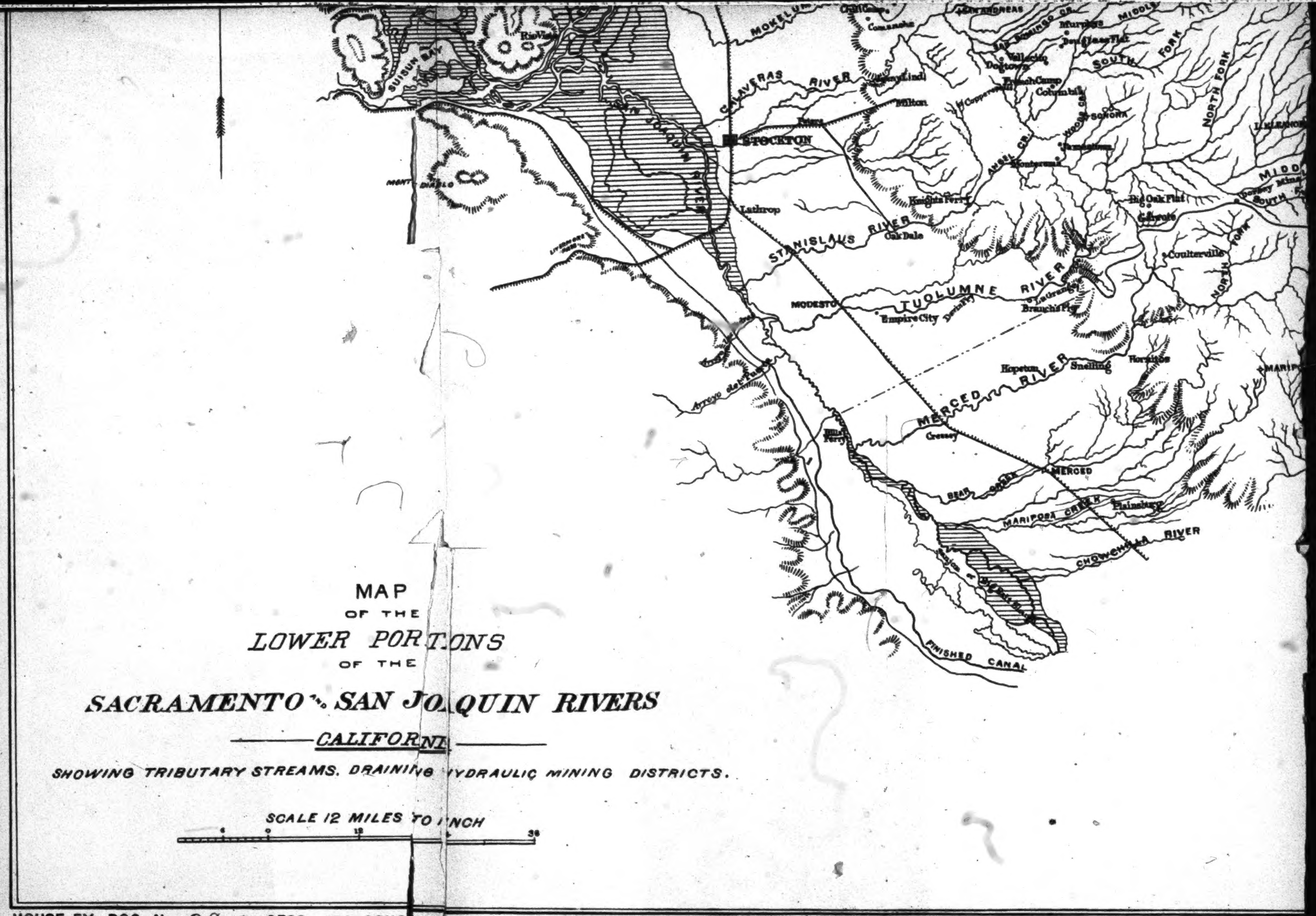
Livermore Pass
TUOLUMNE RIVER
La Grange
Branch's Fy.
MODESTO
Empire City
SOUTH FORK
Hopeton
Snelling
Hornitos
MERCED RIVER
MARIPOSA
Arroyo del Puerto
Hills Ferry
Cressey
MERCED
BEAR CREEK
MARIPOSA CREEK
Plainsburg
CHOWCHILLA RIVER
FINISHED CANAL

ONS

QUIN RIVERS

YDRAULIC MINING DISTRICTS.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SAN DOMINGO CR.
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MIDDLE
Douglass Flat
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Dogtown
SOUTH
FORK
NORTH FORK
CALAVERAS
RIVER
Jenny Lind
Milton
Copperopolis
French Camp
Columbia
Sonora
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SAN JOAQUIN RIVER
ANGEL CR.
Jamestown
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Empire City
La Grange
Branch's Fy
Hopeton
Snelling
Hornitos
MARIPOSA
Arroyo del Puerto
MERCED RIVER
Cressey
MERCED
BEAR CREEK
MARIPOSA CREEK
Plainsburg
CHOWCHILLA RIVER
FINISHED CANAL
SCALE 12 MILES TO 1 INCH
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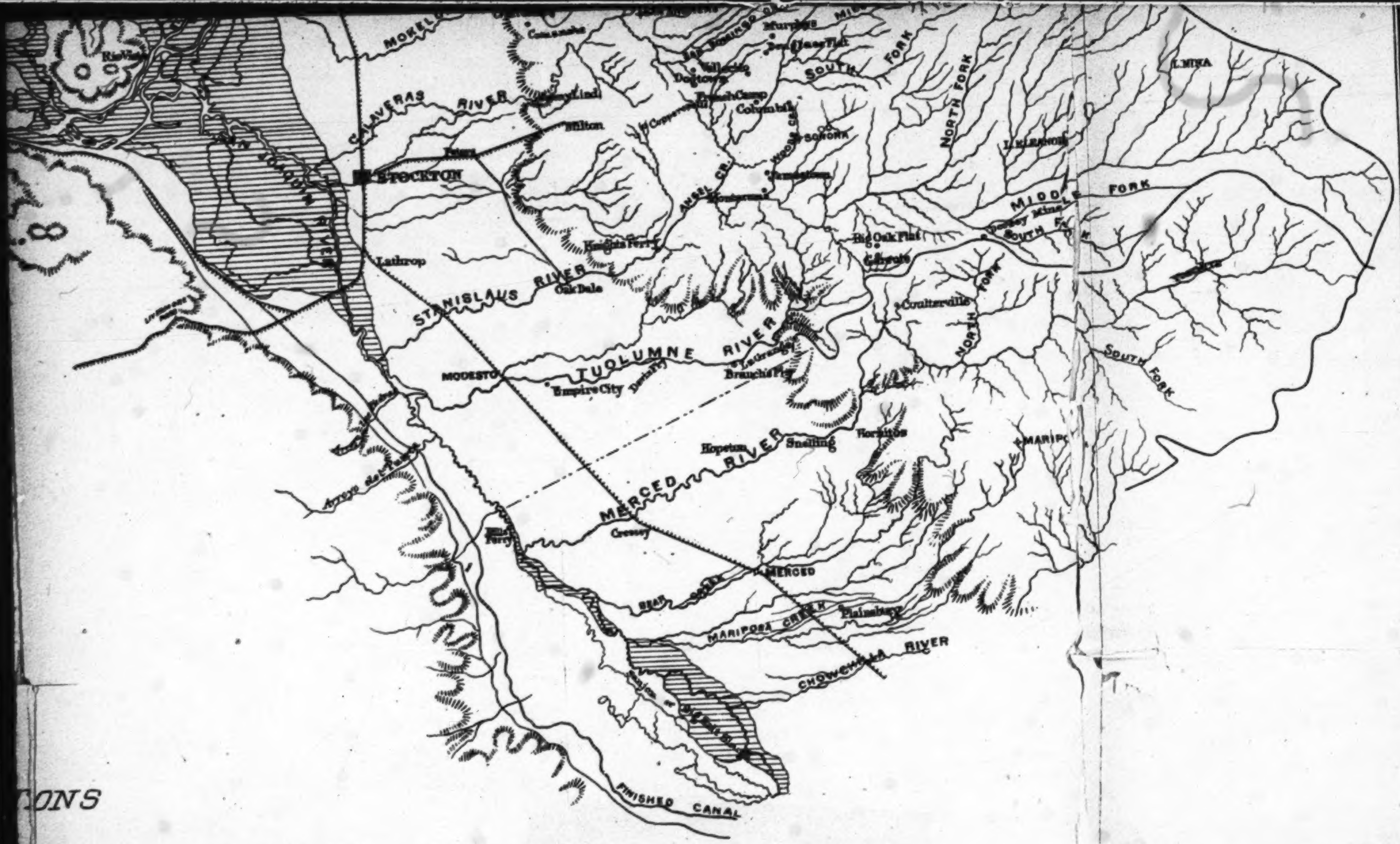
MAP
OF THE
LOWER PORTIONS
OF THE
SACRAMENTO AND SAN JOAQUIN RIVERS
CALIFORNIA

SHOWING TRIBUTARY STREAMS, DRAINING HYDRAULIC MINING DISTRICTS.

SCALE 12 MILES TO 1 INCH

HOUSE EX. DOC. No. 98, 1st SESS., 47th CONG.



MOKEL
Rio Vista
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Copperopolis
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Columbia
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SAN JOAQUIN RIVER
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STANISLAUS RIVER
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TUOLUMNE RIVER
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Empire City
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Branch's Ferry
SOUTH FORK
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MERCED RIVER
MARIPOSA
Arroyo del Puerto
Hills Ferry
Cressey
MERCED
BEAR CREEK
MARIPOSA CREEK
Plainsburg
CHOWCHILLA RIVER
FINISHED CANAL

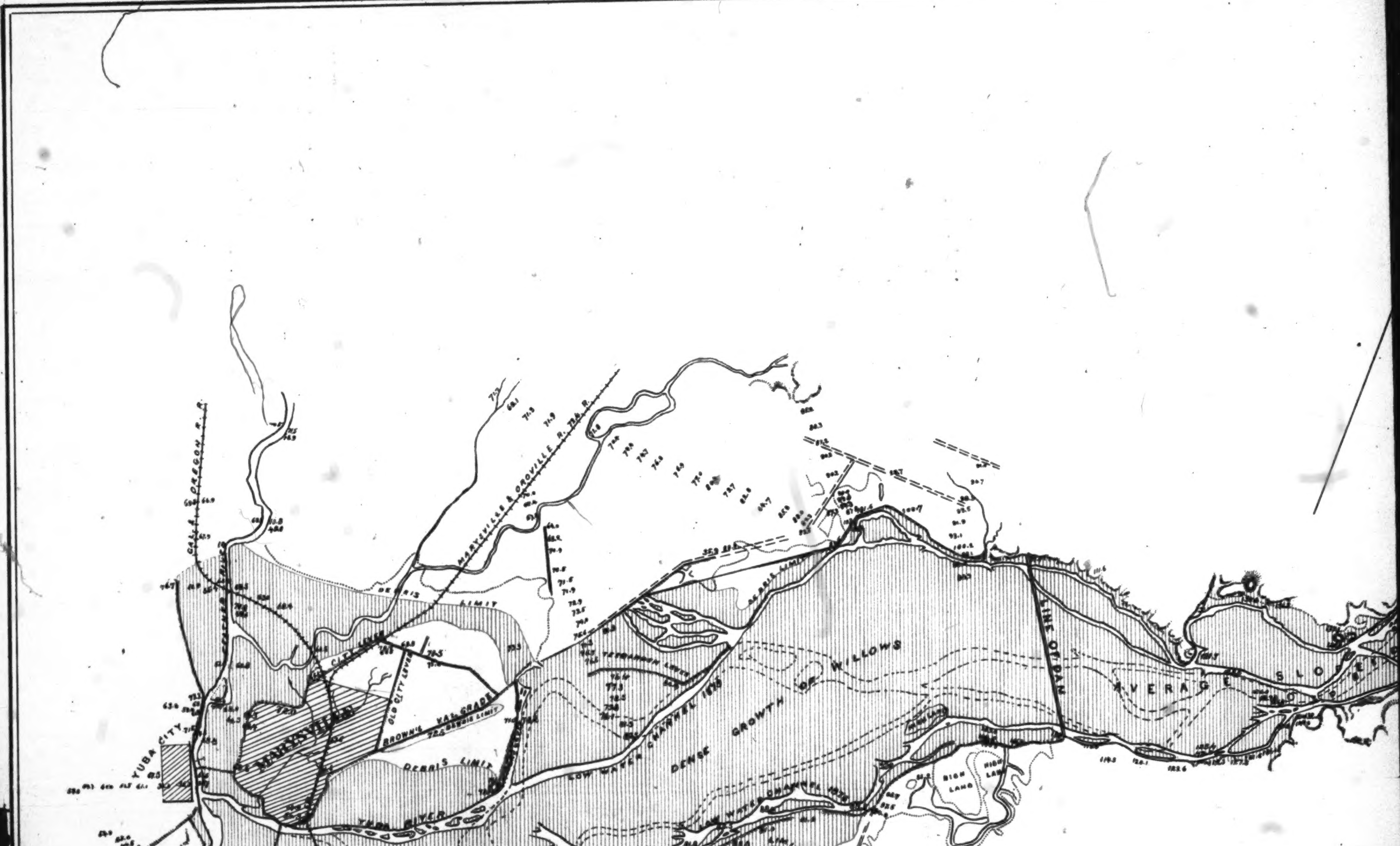
IONS

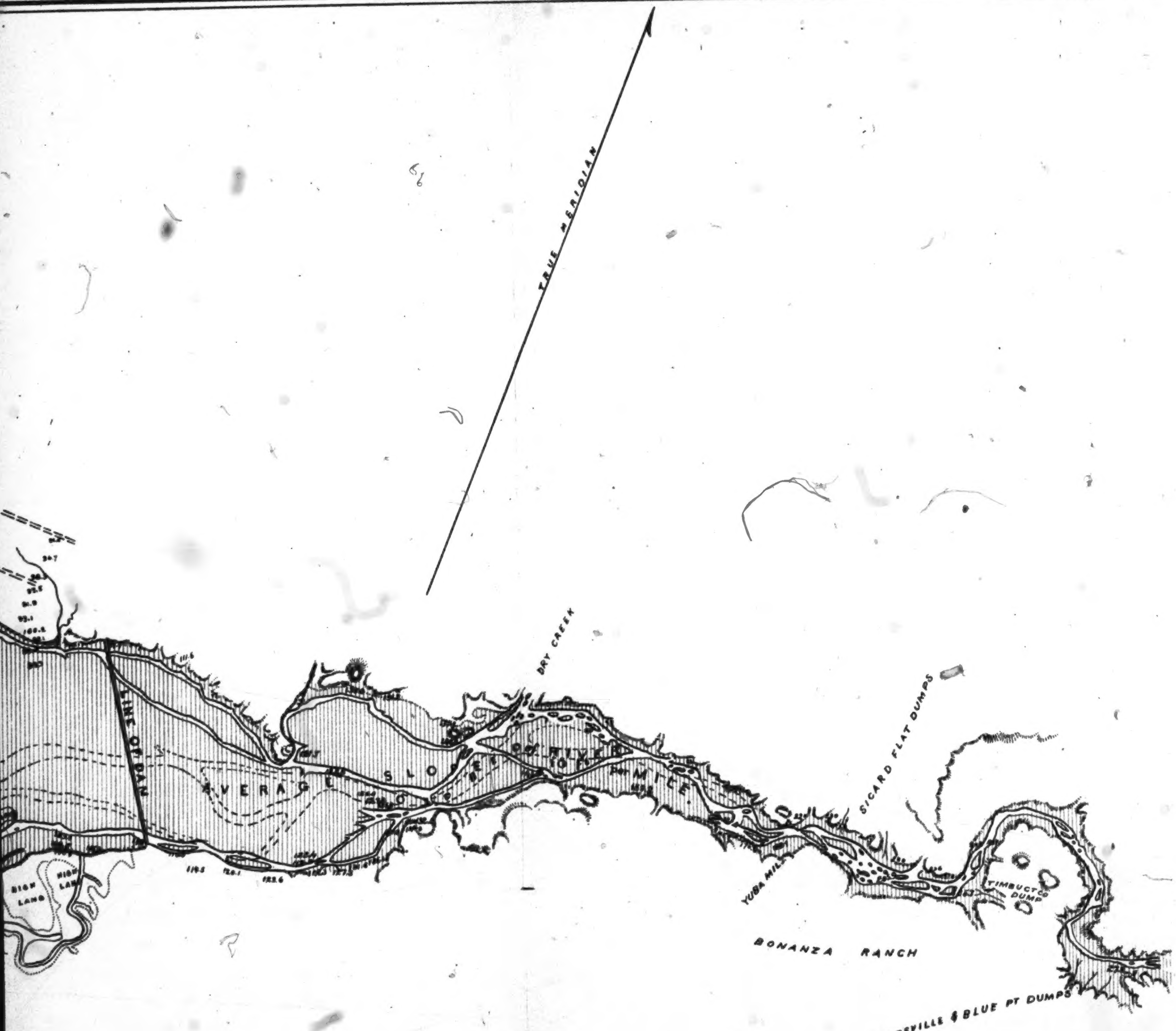
AQUIN RIVERS

HYDRAULIC MINING DISTRICTS.

INCH

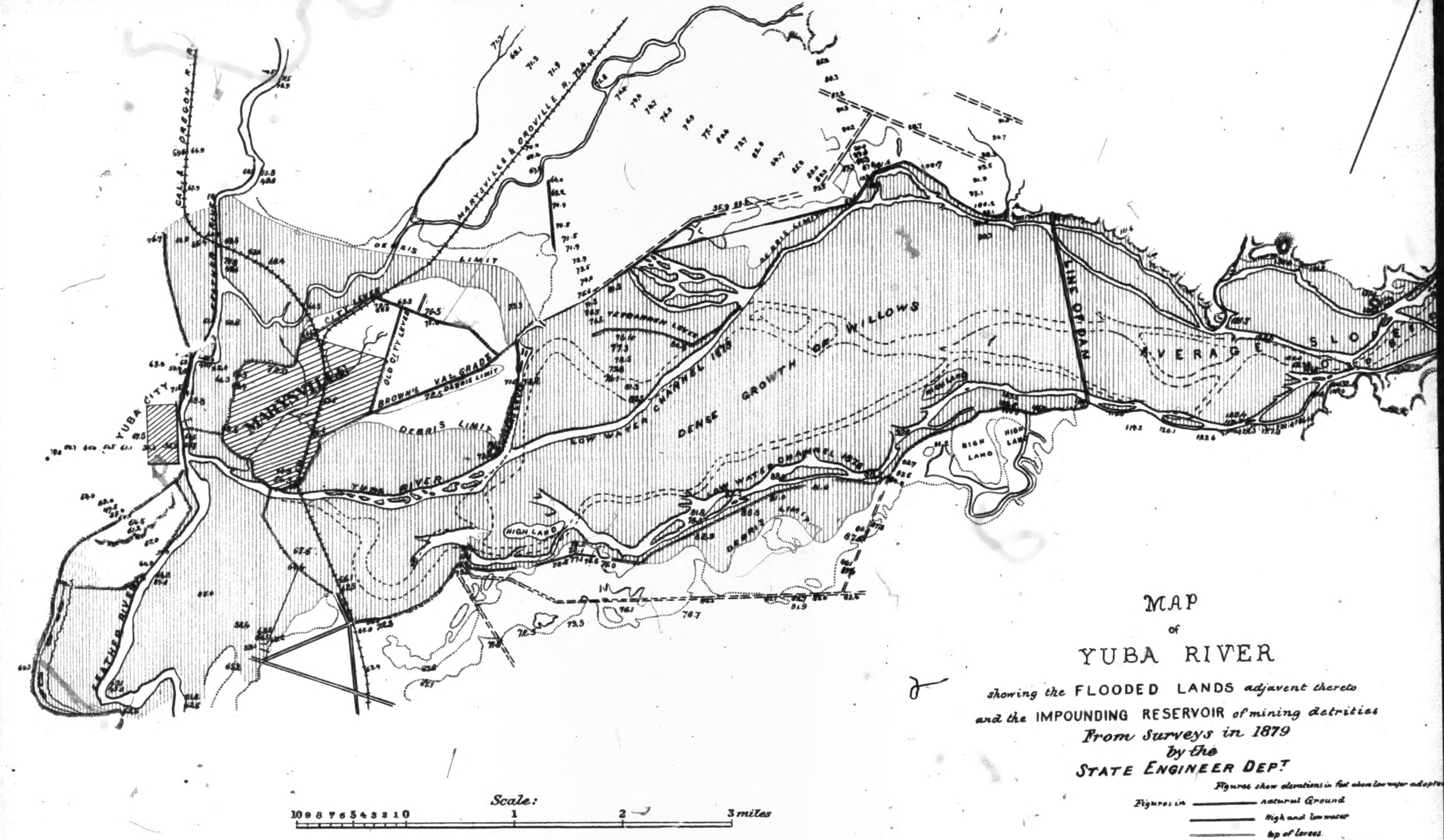
30'


CAL. & OREGON R. R.
YUBA CITY
MARYSVILLE
CITY LIMIT
OLD CITY LIMIT
BROWN'S VAL. GRADE
72.5 DEBRIS LIMIT
DEBRIS LIMIT
MARYSVILLE & OROVILLE R. R.
YUBA RIVER
LOW WATER CHANNEL 1876
DENSE GROWTH OF WILLOWS
LOW WATER CHANNEL 1856
HIGH LAND
HIGH LAND
HIGH LAND
LINE OF DAM
AVERAGE SLOPE
MAP
of

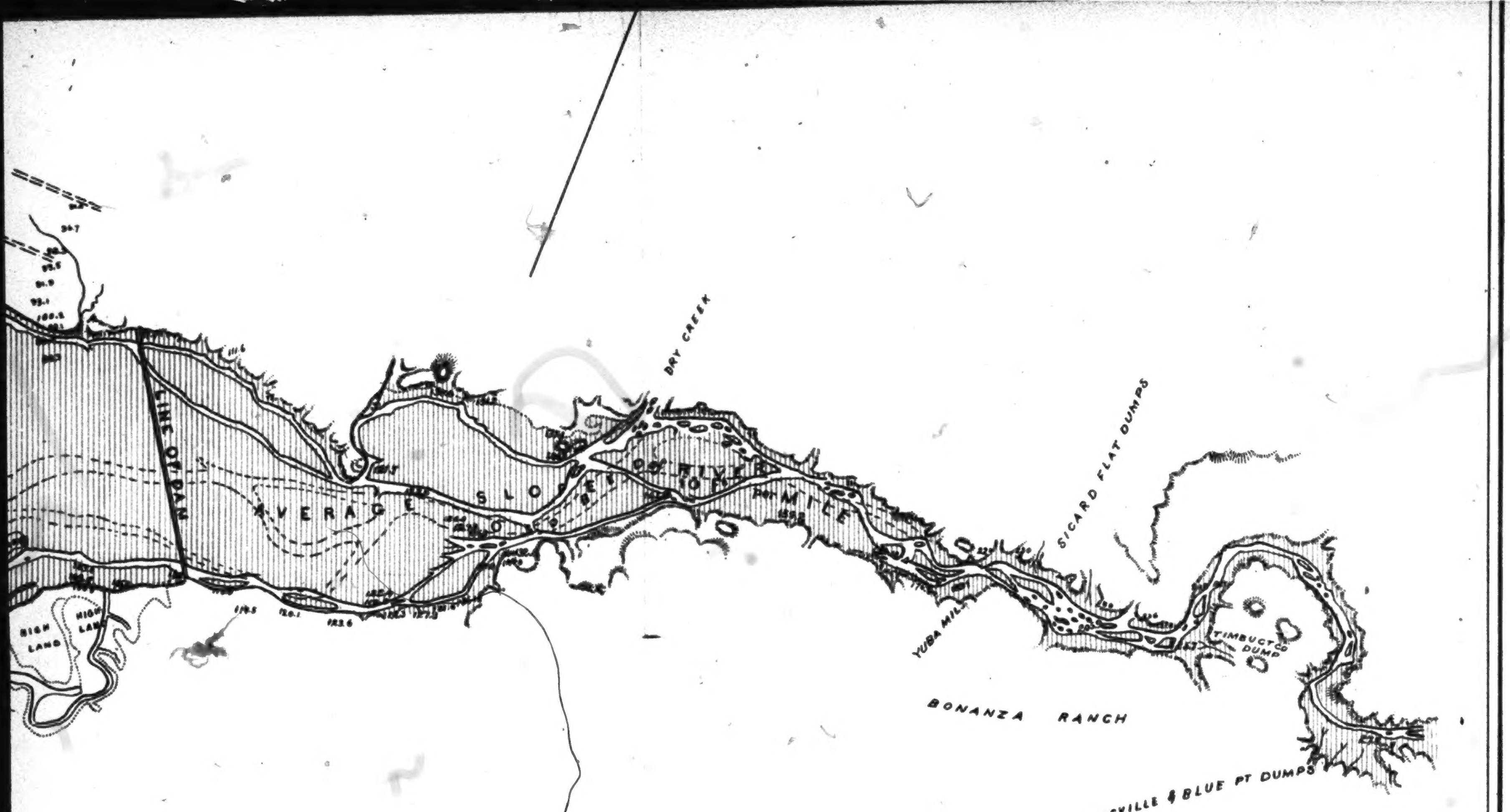

TRUE MERIDIAN
DRY CREEK
LINE OF DAM
AVERAGE SLOPE OF RIVER 10 FT. PER MILE.
SICARD FLAT DUMPS
YUBA MILL
TIMBUCTOO DUMP
BONANZA RANCH
SMARTSVILLE & BLUE PT DUMPS
HIGH LAND
HIGH LAND
119.5
120.1
122.6

MAP

of


YUBA CITY
MARYSVILLE
FEATHER RIVER
YUBA RIVER
CAL. & OREGON R.R.
MARYSVILLE & OROVILLE R.R.
DEBRIS LIMIT
CITY LEVEE
OLD CITY LEVEE
BROWN'S VAL. GRADE
LOW WATER CHANNEL 1879
DENSE GROWTH OF WILLOWS
LOW WATER CHANNEL 1878
HIGH LAND
LINE OF DAM
AVERAGE SLOPE
Scale:
10 9 8 7 6 5 4 3 2 1 0
1
2
3 miles
Figures show elevations in feet above low water adopted
Figures in
natural Ground
High and low water
top of levees.
Limit of floods 1879.

MAP
of
YUBA RIVER
showing the FLOODED LANDS adjacent thereto
and the IMPOUNDING RESERVOIR of mining detrities
From Surveys in 1879
by the
STATE ENGINEER DEPᵀ


DRY CREEK
LINE OF DAM
AVERAGE SLOPE OF RIVER 10 FT PER MILE
HIGH LAND
HIGH LAND
94.7
111.6
119.5
120.1
123.6
SICARD FLAT DUMPS
YUBA MILLS
TIMBUCTOO DUMP
BONANZA RANCH
SMARTSVILLE & BLUE PT DUMPS

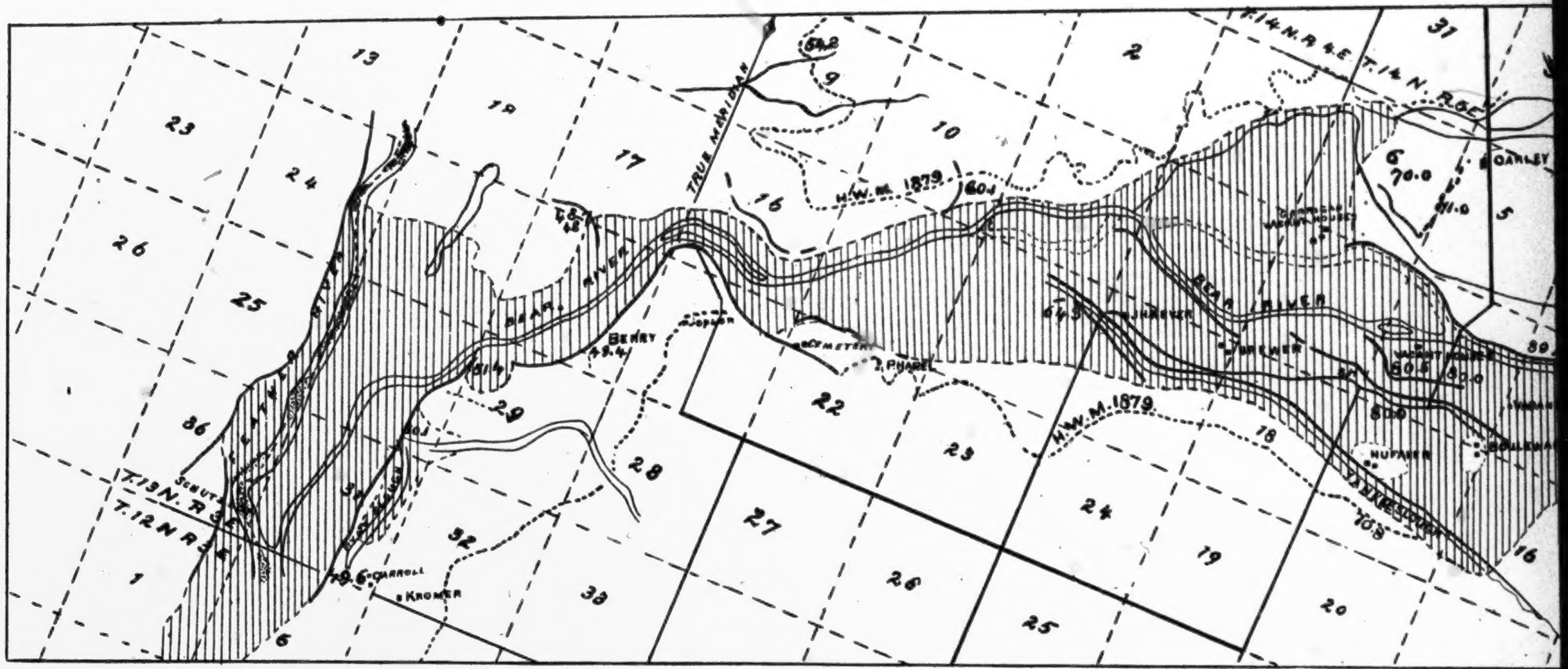
MAP
of
YUBA RIVER
showing the FLOODED LANDS *adjacent thereto*
and the IMPOUNDING RESERVOIR *of mining detrities*
From Surveys in 1879
by the
STATE ENGINEER DEPT.

Figures show elevations in feet above low water adopted at New York landing

Figures in ———— *natural Ground*
———— *High and low water*
———— *top of Levees.*
┈┈┈┈ *Limit of floods 1879.*

MAP
of
BEAR RIVER
showing the
FLOODED LANDS
adjacent thereto

STATE ENGINEERS DEPARTMENT. CAL.


13
23
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6
TRUE MERIDIAN
54.2
9
2
31
10
16
H.W.M. 1879
60.1
T.14 N. R.4 E.
T.14 N. R.5 E.
OAKLEY
6
70.0
81.0
5
T.S.
48
BEAR RIVER
BERRY
49.4
51.4
29
28
27
22
23
24
26
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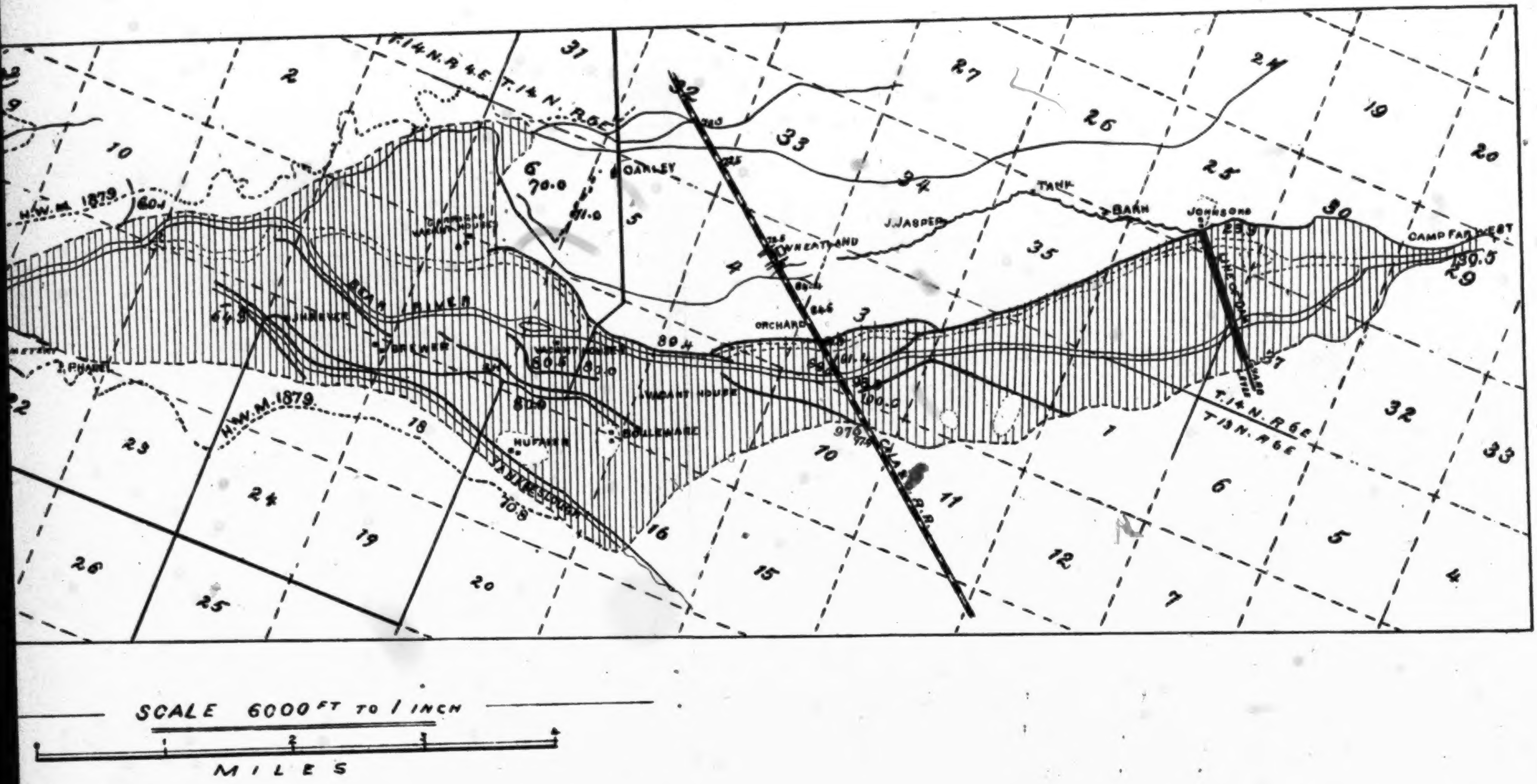
19
20
18
16
32
33
34
T.13 N. R.3 E.
T.12 N. R.3 E.
SCHUTZ
CARROLL
KROMER
79.6
CEMETERY
PHAREL
64.9
BREWER
WARNER HOUSE
60.5
80.0
89
HUFAKER
BOULWARE
H.W.M. 1879
70.8
BEAR RIVER

LEVEES ————
SECTION LINES - - - - -
ROADS ————
SHADING REPRESENTS MINING DETRITUS

SCALE 6000 FT TO 1 INCH

0 1 2 3 4
MILES

HOUSE EX. DOC. No. 98, 1st SESS., 47th CONG.


T.14N.R.4E.
T.14N.R.5E.
T.14N.R.6E.
T.13N.R.6E.
BEAR RIVER
H.W.M. 1879
H.W.M. 1879
OAKLEY
WHEATLAND
J.JASPER
TANK
BARN
JOHNSONS
CAMP FAR WEST
ORCHARD
VACANT HOUSE
VACANT HOUSE
BREWER
BOULEWARE
HUFAKER
CEMETERY
P. PHARE
ST. & C. R.R.
60.1
70.0
81.0
64.5
80.4
80.6
82.0
80.0
70.8
101.4
100.0
97.0
123.9
130.5
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12
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4
32
33
SCALE 6000 FT TO 1 INCH
0
1
2
3
4
MILES